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INTRODUCTION TO SCIENCE

A syllabus of the Northwestern University Freshman Course in Science for Bachelor of Arts students.

Edited by N. E. Bingham as cooperatively planned and presented during the 1947–48 school year by the staff of the course.*

* Members of staff are listed in Preface.

PREFACE

Introduction to Science was developed as a first science course for students enrolled in the Bachelor of Arts program. The majority of these students have major interests in areas other than science. Most of them have taken less secondary school science than the students who enroll in the Bachelor of Science program.

It was planned that, while having a rich experience in science, students would develop an understanding of the nature and scope of science and an appreciation of the methods employed by those active in this field. The five specific objectives originally set for the course served as a guide during its development:

1. To present the scientific method of attacking a problem so that the student will not only understand the method but apply it to problems confronting him.
2. To stimulate the student to think and study in the field of science.
3. To help the student gain information which is essential to an educated individual.
4. To show the student the interrelationships of all the sciences.
5. To give the student a background so that he may intelligently select his second year of science.

Paralleling the development of the course there has been a growing concern on the part of the staff to have the students use the scientific method in acquiring their scientific information.

This course * is given during the winter and spring quarters of the freshman year following a fall quarter of introductory mathematics. In addition to the three lectures and two discussion periods each week, there is a two hour laboratory every other week. The course carries eight quarter hours of credit. Outlines, study questions and reading assignments for each of the lectures were given to each student. Though there were reading assignments in a number of books, Gray, Dwight E., *Man and His Physical World,* and Parshley, Howard M., *Biology,* served as texts.

The staff of the course during the 1947–48 school year included:

Robert M. Garrels, *Chairman,* Assistant Professor of Geology.
N. E. Bingham, Associate Professor of the Teaching of Science.
Robert Bullington, Instructor in Physics.
Maxwell S. Doty, Assistant Professor of Botany.
Nelson G. Hairston, Graduate Assistant in Zoology.
Irving Klotz, Associate Professor of Chemistry.
Wasley S. Krogdahl, Assistant Professor of Astronomy.
Clarence J. Overbeck, Professor of Physics.
Carroll J. Peterson, Instructor in Botany.
William E. Powers, Professor of Geomorphology.
Robert K. Summerbell, Professor of Chemistry and Chairman of the Chemistry Department.

Other members of the staff who shared in the earlier development of the course are:

William Balamuth, Associate Professor of Zoology.
Dorothy Fensholt, Instructor in Chemistry.
Ralph O. Freeland, Associate Professor of Botany.
Oliver J. Lee, Professor of Astronomy, Emeritus.
Albert Wolfson, Assistant Professor of Zoology.

* For additional information concerning the organization of this course as well as several other courses designed for general education see *Science in General Education* edited by Dean Earl J. McGrath, and published by Wm. C. Brown Company, Dubuque, Iowa. This book is a compilation of descriptions of courses designed for general education selected from among those now being given in various colleges and universities.

ORIENTATION

The ultimate goal of science is a unified theory and system of laws which will correlate phenomena in all fields of experience. Such a project can be only an ideal, however, for no man can assimilate the factual information in all the diverse branches of science. In surveying the field, therefore, we shall limit ourselves at any given time to only one important class of phenomena. Nevertheless, we shall not divide our discussions into the rigid classical categories—astronomy, botany, chemistry, geography, geology, physics, zoology—for these divisions are really quite arbitrary and fail to emphasize the unitary nature of science. Since each of these specific disciplines contributes to a full understanding of any given field of facts and events, we shall need to assimilate materials from all of the classical branches of science.

Scientists generally are engaged in two activities: (1) the observation and description of materials and phenomena; (2) the formulation of general laws to correlate these observations. A science is not fully developed, however, until its studies are quantitative; and quantitative expression depends on an understanding of the process of measurement. Our course opens, therefore, with a consideration of the nature of the measurement process. Examples of familiar concepts, such as time and distance, are used, and emphasis is put on the progressive increase in precision of definition and measurement as any field of science develops.

The earliest man who showed any curiosity about his surroundings was undoubtedly first impressed by the many types of matter in nature. As time went on man began to exhibit interest also in the nature of less tangible phenomena which we recognize today as manifestations of energy. Therefore we too shall consider initially the different types of matter and various manifestations of energy.

There are so many individual facts and phenomena in these two fields that it is necessary to group them into various categories and to correlate them by means of general statements called "scientific laws." We shall describe some of these laws. We shall describe also the thought processes by which the intellectual giants of science were led to the development of the fundamental concepts and laws which describe natural phenomena. Then we shall try to integrate different concepts and experimental laws by setting up a theory to account for them. The theory in turn will suggest new experiments which will lead to new classifications of natural phenomena, to new laws and then to revised theories. This process of continuous flux is the distinguishing characteristic of the scientific approach. Thus a theory is not right or wrong; it is either stimulating or non-stimulating toward further research.

Having considered various manifestations of matter and energy, we shall proceed to a discussion of their large-scale organization—the earth, the solar system, the galactic and extra-galactic systems. Here again we shall emphasize the continuous interplay between theory and observation.

As physical science has developed it has become increasingly evident that matter and energy are not independent phenomena but are very closely associated. We shall continue, therefore, with a consideration of various manifestations of these interactions, first in astronomical phenomena, secondly in chemical changes and thirdly in geological transformations. The geological transformations are excellent examples of the meeting of various branches of science—astronomy, biology, chemistry, physics—in a field in which they have been frequently excluded when a narrow scientific point of view has been adopted.

We shall close the first part of the course with a consideration of the present concepts of the *nature* of matter and energy. Theory and experiment are so closely intertwined—each influencing the course which the other follows—that we must describe new phenomena such as radioactivity and electromagnetic radiation. These experimental phenomena are the foundations of current theories of the nature of matter and energy. Nevertheless, we must recognize that the firmly established current theories will lead to new experiments which will extend our horizons of experience, so that we shall be forced to continue to modify our concept of the universe, as well as our conduct as social beings.

The second part of the course pauses with a reconsideration of the nature of the scientific method in the light of the background already established and then proceeds to a further exploration of present concepts regarding the nature of matter and energy. The explorations will continue with a study of solutions and ions, colloids and organic chemistry, all of which are fields which serve as bridges from the physical to the life sciences.

The remaining work of the course is concerned with life and so may be named biology. It is no accident that the study of biology comes at the end of the *Introduction to Science* course, nor does the study of biology at this time in any way violate the integral nature of the course. Because of the dynamic aspects of life it has been impossible to extend the fronts of science in this area as far as has been done in the several physical sciences. So often when one investigates the activities of living creatures, it is necessary to destroy the life, and dead protoplasm is not the same as living protoplasm. Furthermore, all living things vary in so many different ways that it is difficult to establish adequate controls for experiments. Besides, the materials which compose living organisms come from and return to the physical surroundings. Many of the reactions which occur within living things also take place in the laboratory. What is known about the processes that take place in living material has been discovered by the use of the same methods so productive when applied to inanimate materials. Theory and experiment continue to be closely intertwined.

Our study of biology will begin with a consideration of the organization and activities characteristic of all protoplasm. We shall proceed to find out how living things reproduce themselves; how hereditary traits are passed on from generation to generation. We shall then survey the many diversified and complex forms and shall attempt to interrelate and unify these manifestations of our environment and experience by developing the concept of evolution. Finally we shall investigate the various interrelations among different living organisms and between them and their physical environment. The climax of the course will be a discussion of man's place in the natural world.

It is our hope that as a result of this course you will become convinced of the unity of science; that you will develop adequate techniques to continue to grow in your understanding of science and in your ability to use it with increasing effectiveness in your personal and social living.

TOPICS AND LECTURES, 1947–48

I. Measurement
  1. Measurement

II. Matter and Energy
  2. States of Matter
  3. Classification of Matter I
  4. Classification of Matter II
  5. Energy
  6. Heat
  7. Sound and Wave Motion
  8. Light
  9. Uses of Spectra

III. Organization of Matter
  10. Earth Form, Location and Projection
  11. The Solar System
  12. Stars and Galaxies

IV. Interactions of Matter and Energy
  13. Laws of Motion I
  14. Laws of Motion II
  15. Chemical Change—Types
  16. Chemical Change—Rate
  17. Nature of an Earth Science
  18. Energy Cycles in the Earth
  19. Cycles of Matter Transfer in Earth
  20. Matter and Energy Through Time on Earth
  21. Earth's Surface Features
  22. Physics of the Atmosphere
  23. Weather

V. Nature of Matter and Energy
  24. What is Electricity
  25. Electrons at work
  26. Radioactivity
  27. Atomic Structure
  28. Electromagnetic Spectrum
  29. Nuclear Energy
  30. Nature of the Scientific Method
  31. Solution and Ions
  32. Colloids
  33. Organic Chemistry

VI. Organization and Activities of Protoplasm
  34. The Characteristics of Living Organisms
  35. The Biological Units of Structure and Activity
  36. The Activities of Living Organisms
  37. Respiration
  38. Photosynthesis
  39. Source of Foods
  40. Utilization of Foods
  41. Chemical Regulation

Lecture 1 MEASUREMENT

A. Nature of Science
   1. The scientific method: steps, application, method vs. material, progress by successive approximation
   2. What the natural sciences include
B. Measurement as a requirement in science
   1. The need for measurement
   2. Measurement a numerical expression of a comparison
C. The fundamental quantities
   1. Lengths: how measured, specification of units essential, units of length, auxiliary means of measurement
   2. Mass: What mass is, how measured, units of mass, indirect methods of measurement
   3. Time
      a. Units: the day and the year; hours, minutes and seconds
      b. How measured: by clocks; by stroboscopes, oscillators, et al.; by calendars
D. Derived quantities: area and volume, velocity, power
E. Special units
   1. Special units peculiar to certain quantities
      a. Temperature
         (1) Length of liquid column merely an index of temperature
         (2) Fahrenheit, Centigrade and Absolute scales
         (3) Extremes
      b. Dollars and cents
   2. Special units in derived quantities
      a. Degrees per hour
      b. Dollars per ounce
F. Use of units
   1. Numerical results meaningless without statement of units.
   2. Appropriateness of units
G. Errors of measurement: blunders, random errors, systematic errors
H. Assimilation of measurements: tables, graphs and charts, equations

Lecture 2 STATES OF MATTER

A. Many diverse types of matter: evident even to early man
B. Need for some method of orderly arrangement
   1. Predominant importance of sight among the senses
      a. Early classifications in terms of color
      b. Faults of color classification
   2. Classification in terms of state: a shape classification
      a. Definitions of three states (solid, liquid, gas) in terms of shape properties
      b. Transitions from one state to another (ice, water, steam), conversion of air to liquid air
C. Criterion of useful classification: members of a category should have similarities other than those by which they have been so classified; consideration of such similarities for one of the above states
D. The gaseous state: present conception reached after several successive theoretical formulations had been modified or displaced: an example of the application of the scientific method

1. Early experiments in pneumatics:
   a. Use of concept "nature abhors a vacuum"; limitations of this concept in accounting for limits of pump action
   b. Invisible cord concepts of lifting water
   c. Development of concept that air has weight
   d. Critical experiments illustrating weight of air
2. Development of concept of pressure of gas
3. Increase in precision of experimental measurements on gases: Boyle
4. Formulation of quantitative expressions ("laws") of behavior of gases
5. Development of kinetic-molecular theory: introduction of concept of moving molecules as a framework for correlating qualitative and quantitative behavior of gases
   a. Extension to liquids and solid: introduction of concept of intermolecular forces
   b. Extension to field of chemical reactions: to be discussed subsequently
6. Breakdown of kinetic-molecular theory with accumulation of more precise measurements: new laws and new theories

E. Summary of discussion of gaseous state with emphasis on continual modification of theory by new experiments; dynamic character of the scientific method.

Lecture 3 CLASSIFICATION OF MATTER I

A. Need for classification of materials on the basis of their transformations
1. Demonstrations of differences in behavior
   a. Oxygen, hydrogen, and carbon dioxide in a flame
   b. Sulfur and sugar in water
   c. Iron, sulfur, wood, and ammonium dichromate in flame
3. Early classifications of materials in terms of single fundamental principles: Evidence that water is a primordial substance
   a. Both a gas and a solid from water
   b. Fish apparently grow from water
   c. Plants apparently gain weight from water only
4. Multiple-principle theory: the earth, air, fire, and water of Aristotle

B. Development of experimental aspects of classification of materials
1. The alchemists
   a. Concept of the philosopher's stone
   b. The alchemists advanced science
2. The iatrochemists and emphasis upon chemicals as medicines

C. Boyle's concept of an element: any substance that could not be decomposed by any known means

D. The nature of the process of burning
1. The phlogiston theory
   a. The nature of the theory
   b. Its strength and weaknesses
2. Lavoisier's contribution
   a. Emphasis upon role of oxygen
   b. Development of idea of compound

E. Classification of matter into categories established by operational definition
1. Heterogeneous: non-uniform properties
2. Homogeneous: uniform properties
   a. Solutions: variable composition

b. Substances: fixed composition
(1) Compounds of two or more elements
(2) Elements

Lecture 4 CLASSIFICATION OF MATTER II

A. The development of quantitative relations
1. Experimental weight laws
a. Constant composition
b. Conservation of mass
2. The atomic theory: developed by Dalton
a. Fundamental postulates:
(1) Elements composed of atoms
(2) All atoms of given element have same weight
(3) Atoms combine to form molecules
b. Problem of finding weights of known elements
c. The theory explained known facts
d. It did not explain many new problems

B. Classification of the elements
1. Distinction between metals and non-metals; limited in usefulness
2. Relations in physical and chemical properties in groups of elements
a. Similarity of helium, neon, and argon
b. Similarity of lithium, sodium, and potassium
(1) Demonstration of their reaction in water
(2) Their behavior in the production of compounds
3. Concept of octaves
4. Mendeleef's Periodic Table

C. Symbolic representation of different kinds of matter: symbols, formulas, equations

Lecture 5 ENERGY

A. Energy, work and power: Matter and energy two fundamental quantities in nature
1. Definitions
a. Work=force$\times$displacement
b. Power=work/time; horse power=550 foot pounds per second (demonstrated power of man lifting 50 pound bags of sand)
c. Efficiency=output work/input work
2. Units: foot pound, inch ounce, dyne-centimeter=erg

B. Sources of energy, magnitude and availability
1. Gravitational pull of moon
2. Internal energy of earth
3. Solar energy: radiation heating, wind and water power, photosynthesis, fuel resources
4. Nuclear disintegration: one pound of matter completely converted into energy is equivalent to the energy released in the burning of about one million tons of coal

C. Forms of energy
1. Potential: gravitational, molecular strain, chemical, electrical
2. Kinetic: linear and rotational, atomic and molecular

D. Transformations of energy: law of conservation of mass-energy, friction and efficiency

Lecture 6 HEAT

A. Subjective vs. objective determination of temperature: feeling of hotness or coldness depends upon immediate past experience

1. Galileo's thermoscope and the inauguration of the scientific study of heat
2. Temperature scales and ranges:
    a. Fahrenheit, Centigrade, and Absolute scales
    b. Examples of temperatures in degrees Centigrade: interior of hot stars—millions of degrees, atom bomb—millions of degrees, melting point of iron—1535 degrees, melting point of tin—232 degrees, boiling point of water—100 degrees, freezing point of water—0 degrees, freezing point of mercury— —40 degrees, boiling point of liquid air— —192 degrees
3. Absolute zero

B. What is heat?

1. The caloric fluid theory (that heat is a weightless fluid) fails the experimental test:
    a. Count Rumford's observations when boring cannon
    b. Humphrey Davey's observations when melting ice by rubbing it
2. Heat—a form of energy

C. Distinction between heat and temperature

1. Heat is energy—it is the sum total of the kinetic energies of the random motion of the particles of a material
2. Temperature is a measure of the degree of activity of this random motion

D. The calorie and heat capacity per gram of substance

1. Definitions
2. Specific heats: water 1.0, iron 0.1, lead 0.03, rock (approximately) 0.2 (demonstrated by having equal masses of lead, zinc, brass and iron balls which had been heated in boiling water, melt way into or through blocks of paraffin)

E. Effect of adding heat energy

1. Temperature change
2. Change in physical properties (demonstrated change in color; expansion of iron wire; unequal expansion with thermostat)
3. Change of state and latent heat
    a. Latent heat of vaporization of water, 540 calories
    b. Latent heat of fusion of water, 80 calories

F. Method of heat transfer: conduction, convection and radiation

G. Two laws of thermodynamics

1. When heat is transformed into some other form of energy or some other form of energy is transformed into heat, there is an exact proportionality between the energy which disappears and that which is produced at its expense
2. Any time that heat flows of its own accord it moves from where the temperature is higher to where it is lower

LECTURE 7 SOUND AND WAVE MOTIONS

A. What is sound?

1. Subjective aspect—sensation
2. Objective aspect—wave motion of matter

B. Three divisions of study

1. Source: always a vibrating (elastic) body
2. Carrier
   a. Elastic material (demonstrated by bell in evacuated bell jar); velocity in air approximately 1120 feet per second, in hydrogen 4× velocity in air, in steel 15 times velocity in air
   b. Fundamental wave equation: velocity = number of vibrations per second×wave length (demonstrated image of vibrating string on wall by means of rotating disk with lenses)
3. Receiver: the ear, electrical apparatus

C. Frequency and intensity range of ear

1. Frequency range from 16 to 16,000 vibrations per second, changes with age, varies with individuals
2. Intensity: vibration can be heard if amplitude of motion is approximately the diameter of a gas molecule; can detect ½ million gradations of intensity and frequency; can hear energy values of a million million range of intensity

D. Objective and subjective sound patterns (demonstrated with oscilloscope)

1. Pitch from frequency
2. Loudness from displacement or amplitude of wave
3. Quality from pattern of wave

E. Physical basis of music

1. Musical sound is one in which a relatively simple wave pattern tends to repeat itself
2. Noise sounds have very complex patterns
3. Pleasing effect is produced by the simultaneous sounding of different frequencies if they are in the ratio of small whole numbers (known by Pythagoras 600 B.C.)
   a. Octave ratio, 1/2
   b. Triad ratio, 4/5/6
4. Beats: number of beats per second represents the difference in frequencies (demonstrated beats)

F. Resonance and the Doppler effect (demonstrated resonances with matched tuning forks mounted on resonance boxes), (demonstrated Doppler effect with rotating whistle)

1. Resonance is produced by the additive feeding energy from one system to another of the same frequency
2. Doppler effect is an apparent change in frequency due to relative motion between receiver and source

LECTURE 8 LIGHT

A. Introduction: Most of our knowledge of outer world is acquired through light

B. What is light?
   1. Ancients believed that eye projected invisible fingers
   2. Corpuscular theory of Newton—tiny particles of material shot out from or bounced off object that we see
      a. Theory requires that light travel in a straight line
      b. Theory fails to account for bending of light around corners (diffraction) characteristic of waves; also fails to account for constructive and destructive interference
   3. Wave theory (demonstrated interference by having students look at a distant light source through slit between fingers)
      a. Velocity=frequency×wave length
      b. While wave length of sound is about 60 cm., that of red light is .00006 cm.
   4. Quantum theory: light energy is emitted in definite unit quantities; energy per quantum in ergs=Plank's constant×frequency of vibration

B. Measurement of the velocity of light
   1. Early attempts and first success
      a. Ancients could not be sure whether or not light transfer was instantaneous
      b. Galileo and assistant tried to measure it but method was too crude to determine velocity
      c. Römer (1676) first determined velocity by series of observations on the time of the eclipses of the satellites of Jupiter
   2. Velocity in vacuum and material substances
      a. In vacuum or air, 186,000 miles per second
      b. In water, 140,000 miles per second
      c. In glass, 125,000 miles per second
      d. In diamond, 70,000 miles per second

C. Direction of propagation: uniform medium, reflection, refraction
   1. For all practical purposes light travels in a straight line in a uniform medium
   2. Incident and reflected angles are equal (demonstrated by projecting slit of light against mirror mounted on disk that is slowly rotated)
   3. Refraction: a change in direction of light when it enters a medium of different optical density

D. Path of light through prisms and lenses (demonstrated path of light through various prisms, then through prisms placed base to base); in a converging lens, 1/ object distance plus 1/ image distance=1/ focal length (demonstrated path of light through a double convex and double concave lens)

E. Spectra (demonstrated that narrow beam of light is split by prism and by diffraction grating)
   1. Types: continuous, bright line, dark line (demonstrated bright line spectrum of mercury vapor)
   2. Interpretation of absorption spectra: cool gas absorbs wave lengths it emits when hot
   3. The spectrum is the light "signature" of a substance

F. Doppler effect

G. Phenomena of wave motion: Interference, diffraction

LECTURE 9 THE USES OF SPECTRA

A. Spectroscopy as a means to much information
   1. Analogy of the analysis of sound
   2. Similar analysis of light
B. Spectrum formation: by refraction in a prism, by diffraction in a grating
C. Review of types of spectra: continuous spectra, bright-line spectra (emission spectra), dark-line spectra (absorption spectra)
D. Impurity of spectra: wide source, divergent beam
E. The spectroscope
F. The laws of spectrum analysis
   1. Continuous spectrum from a glowing solid, a glowing liquid or a glowing opaque gas
   2. Bright-line spectrum from a glowing transparent gas
   3. Dark lines of absorption from a cooler material between observer and a continuous spectrum
G. Determination of
   1. Temperature
   2. Chemical composition
   3. Quantitative analysis
      a. Elements or compounds
      b. Advantages: can be done rapidly, used on small samples, permanent record
H. Basis of quantum theory
I. Astronomical uses—to determine temperature, chemical composition, radial velocity, rotation, pulsation, stratification, multiplicity, mass, diameters, distances

LECTURE 10 EARTH FORM, LOCATION AND PROJECTION

A. "Figure" of the earth, oblate spheroid or spheroid of rotation: radius, ellipticity, density distribution
   1. Proofs of earth's spheroidal shape
   2. Measurement of the size of earth from length of degree
   3. Measurement of earth's radius by ancients: Eratosthenes (276–196 B.C.)
B. The problem of location on the earth's surface
   1. Global coordinates, or the earth grid: latitude and longitude, meridians and parallels, variations in lengths of degrees
   2. Determination of position, as in navigation
      a. Latitude: by zenith angle of position of *noon* sun, or of Polaris, or some other star
         (1) at equinoxes
         (2) at solstices
         (3) at times other than equinox or solstice
      b. Longitude: by comparison of solar time of unknown point with time at known longitude
   3. Direction and distance
      a. True direction vs. magnetic direction
      b. The statement of direction: in quadrants, as azimuth
      c. Measurement of distance by triangulation
         (a) with 90° triangle
         (b) not with a 90° triangle
         (c) Law of Sines

C. The problem of projection: flat maps developed from round world
   1. Earth grid vs. map grid
   2. Desirable characteristics in a map projection: area, shape, distance, direction
   3. Examples of projections or schemes for developing earth's surface on flat paper
      a. Mercator—a cylindrical projection, qualities: conformal, straight lines are rhumb lines
      b. Gnomonic plane projection, properties: straight lines are great circles, scale and direction *vary greatly* in different parts of map
      c. Other types of projections—the 3 great groups of projections: cylindrical, plane, conic—also others

LECTURE 11 THE SOLAR SYSTEM

A. Contents, arrangement, and scale of the solar system
B. Movement of the system in accordance with the law of gravitation
   1. Kepler's laws of planetary motion
      1. Law of ellipses
      2. Law of areas
      3. Harmonic law: $P^2 = (m+m)d^3$ where p is period of revolution, m is in solar mass units, and d is in astronomical units
   2. Importance of Kepler's laws
      1. Apply to any two reacting bodies
      2. Led to discovery of law and gravitation
         a. From law of equal areas—gravitation is directed along a line joining two bodies
         b. From harmonic law—amount of attraction in proportion to product of masses
         c. From law of ellipses—attractive force diminishes in proportion to square of the distance
   3. Law of gravitation
      1. Statement of law: $F \propto \frac{m_1 m_2}{d^2}$; $F = G \frac{m_1 m_2}{d^2}$
      2. Used to weigh earth
C. The earth-moon
   1. The earth: rotation, revolution, seasons
   2. The moon: revolution around earth, phases of moon, eclipses, tides; rotation on axis; distance, diameter, surface area, volume, mass and quality; lunar features and surface conditions
D. The planets and their satellites
   1. Mercury: size, temperature, rotation, orbit
   2. Venus: size, mass, perpetual clouds, no evidence of water
   3. Mars: size, mass, day length, temperatures, atmosphere, polar caps, seasons, satellites
   4. Jupiter: size, mass, markings, rotation, ellipticity, central condensation, atmosphere, satellites
   5. Saturn: rings, diameter, mass density, bulge, central condensation, atmosphere, satellites
   6. Uranus: discovery, size, satellites, oblateness
   7. Neptune: prediction, size, satellites
   8. Pluto: search and discovery
E. Comets: irregular form, structure, variable dimensions, small mass low density, high eccentricity, number, period, relation to meteor storms

F. The sun: distance, luminosity, temperature, mass, composition of atmosphere, appearance, interior, source of energy

Lecture 12 STARS AND GALAXIES

A. The stars as suns
   1. The distances to stars
      a. Units of distance
      b. Distance of certain stars
      c. Determination of distance by parallax
      d. Other methods of determining star distance
   2. Sizes of stars
   3. Temperatures of stars
   4. Masses of stars
   5. Chemical composition of stars
   6. The motion of stars
   7. Variable stars

B. The number and arrangement of stars
   1. Familiar constellations
   2. What the telescope reveals

C. Other forms of matter in the universe
   1. Planetary nebulae
   2. Diffuse nebulae
   3. Interstellar matter

D. The Milky Way system
   1. Relation of the Solar system to the Milky Way
   2. The Milky Way in relation to other Galaxies

E. Other galaxies

F. Modern cosmology

Lecture 13 LAWS OF MOTION I

I. The laws of motion
   A. Historical concepts: motion as an unnatural condition, work of Galileo
   B. Explanation of terms
      1. Velocity as rate of traversal of distance with time
      2. Acceleration as rate of increase of velocity
      3. Deceleration as rate of decrease of velocity
   C. Newton's first law: acceleration implies the application of an unbalanced force
      1. Force as push or pull
      2. A force needed to change either speed or direction
      3. Inertia of rest and of motion
      4. Familiar examples of the law
      5. The influence of friction
   D. Newton's second law: on a free body a force produces an acceleration proportional to the force and inversely proportional to the mass of the body
      1. The influence of force upon acceleration
         a. Units of force; poundal and dyne
      2. The influence of mass
      3. Acceleration due to gravity
      4. Illustrations of the law
   E. Newton's third law: total momentum is conserved
      1. Momentum as mass times velocity
      2. Illustrations of the law: firing a rifle, the rocket

Lecture 14 LAWS OF MOTION II

A. Application of Newton's laws to rotational motion
   1. Rotation and revolution
   2. Centrifugal vs. centripetal force
      a. Equation for centrifugal force
      b. Applications and examples of centrifugal force
   3. Internal forces in a rotating system
   4. Comparison of linear and angular motion
      a. Distance and angular distance
      b. Velocity and angular velocity
      c. Acceleration and angular acceleration
      d. Force and torque
      e. Mass and moment of inertia
   5. Re-statement of Newton's laws in terms of rotational motion

B. The laws of motion as the basis of mechanics
   1. Dynamics concerned with bodies in motion
      a. Some familiar examples
      b. Celestial mechanics
   2. Statics concerned with bodies at rest
      a. Applications in bridge-building and architecture
   3. Hydro-mechanics deals with liquids
   4. Aero-mechanics deals with gases

C. Modern refinements of the Newtonian mechanics
   1. The laws require modification when considering:
      a. The motion of very small masses
      b. Motion at very high velocities
   2. The theory of relativity
   3. Transformation of mass into energy
   4. The quantum mechanics

Lecture 15 CHEMICAL CHANGE-TYPES

A. Introduction
   1. Recollection of method of classification of matter: direct attention to compounds as substances of definite composition
   2. Conversion of compounds into other substances, and of elements into compounds as manifestations of interactions of matter and energy

B. Methods of producing chemical transformations
   1. Mixing: examples of production of precipitates, colors, gases, coatings
   2. Heating: examples of lack of reaction at room temperature but violent transformation upon heating
   3. Electrical energy: electrolysis of water
   4. Mechanical methods: pressure
   5. Light: photosynthesis

C. The problem of representation of transformations by a suitable notation
   1. Need for symbolic notation to allow concise representation
   2. Adequate chemical symbolism (formulas and equations) had to wait until the development of concept and methods of quantitative analysis
   3. Significance of a chemical equation
      a. Shorthand representation of the transformation
      b. Atoms and molecules as theoretical counterpart of substances involved

c. Balanced equations as expression of conservation of mass
4. A good notation should also be suggestive
a. In classification of the multitude of chemical reactions
b. In prediction of new transformations and of properties of new compounds

D. Classification of chemical reactions

1. Combination	5. Double displacement
2. Decomposition	6. Neutralization
3. Displacement	7. Hydrolysis
4. Reduction	8. Polymerization

E. Applications to preparation of new substances
1. Cracking process in petroleum
2. Production of synthetic plastics, rubbers, fibers
3. Preparation of new pharmaceuticals

F. Limitation of present symbolic notation and chemical theory: inadequacy of prediction, particularly of biochemical behavior

Lecture 16 CHEMICAL CHANGE—RATES

A. Examples of variation in rate of chemical change
1. Sugar will melt in gas flame without burning, yet oxidizes in body at low temperature
2. TNT will melt in gas flame, mechanical stimulus is needed for explosion
3. Rate of decomposition of hydrogen peroxide is dependent upon several factors

B. Methods of correlating experimental data on rate of change
1. Tabular arrangement
2. Graphical representation
3. Concise notation using calculus

B. Factors which influence velocity of chemical transformation
1. Concentration
a. Increase in concentration increases the speed of a reaction (candle burning in air and in oxygen)
b. Increase in surface area of solid material increases speed of reaction (hot wire in oxygen and steel wool in oxygen)
2. Temperature—rule that raising temperature 10° C. doubles rate of reaction (demonstrated increase in rate of decomposition of hydrogen peroxide when heated in boiling water)
3. Catalysts—substances that speed up a reaction without themselves being used (demonstrated burning of lump of sugar with cigarette ashes on it); catalysts in body known as enzymes

C. Theory of reaction kinetics: extension of kinetic-molecular theory
1. To explain rate of reaction need an additional postulate: collisions of molecules necessary for chemical reactions
2. To account for effect of temperature need an additional postulate: all molecules collide, but to react, molecules must have high velocities; such molecules are said to be activated. Then the number of activated molecules doubles with an increase in temperature of 10° C.

D. Special phenomena
1. Spontaneous combustion (demonstrated combustion of paper soaked in solution of white phosphorus in carbon disulfide)
a. The requirements
1. Combustible material

2. An exothermic reaction
3. Insulation

b. Theoretical explanation

2. Explosion (demonstrated by activating a balloon full of hydrogen and oxygen)

E. Importance of study of chemical change
1. The modification of materials: synthetics
2. Understanding living processes

Lecture 17 THE NATURE OF AN EARTH SCIENCE

A. Dependence of earth science upon the basic sciences: geologists are interested in any and all relationships present on earth while physicists and chemists are interested in fundamental properties that ramify through all of nature

B. The problem of handling natural data
1. Controlled systems in laboratory studies
2. Necessity for acceptance of raw data in earth science
3. Problems of gathering and selection of earth data
   a. Sampling problem (How many samples are necessary before the sample is a fair representation of the aggregate of a beach?)
   b. Analysis (What characteristics of sand can be used that give clues to the past history of the earth?)
      (1) Sort sand by screens according to size
      (2) Plot per cent of sand of each size
      (3) Interpret results: get one distribution if deposited along a shore; a second distribution if deposited along a river; a third distribution if deposited by ice
   c. Inaccessibility problems: can procure samples near surface, but most of material entirely inaccessible
   d. Scale problem
      (1) Analogy: size of man is to earth as bacterium is to orange
      (2) Map: a device for shrinking area—area varies as the square of distance, if length is reduced by 10 then area is reduced by 100
      (3) To make scale model of mountain range—volume varies as the cube of distance, if length is reduced by 10, then volume is reduced by 1000. Weight varies with the volume
      (4) Certain factors vary as distance, others as area, others as volume
         (a) Illustrate with problem of what would happen to man if we reduced his size (height) by a factor of 50
         (b) Illustrate the characteristics of a true scale six inch model of the earth. Reduction factor 80,000,000; crushing strength of earth (300,000# per square inch) is reduced to .0037# per square inch

C. The problem of geologic time
1. Necessity for working assumption of conditions in the past
2. Methods devised to search into the past

Lecture 18 ENERGY CYCLES IN THE EARTH

A. Evidences of earth energy: wind, waves, volcanoes, earthquakes

B. Sources of earth energy
1. External: sun, moon, stars, cosmic rays
2. Internal: radioactivity, shrinkage

C. External energy
   1. Water cycle (plot energy relationships)
      a. Trace potential energy changes of a drop of water from ocean back to ocean
      b. Trace kinetic energy changes of a drop of water from ocean back to ocean
   2. Wave energy (plot energy relationships)
      a. Absorbed by wind
      b. Transmitted by waves to shore without loss
      c. Dissipated on shallow bottom and beach
D. Gradational process in geology
   1. Result of solar energy a continuous loss in potential energy of solid earth
      a. Wave action reduces level of shore
      b. By water cycle materials are carried to lower level
E. Cycles of internal energy—evidenced in cyclic periods of mountain building
   1. Energy released in volcanic eruptions
      a. Amount of ice melted in Iceland by a single eruption (4 cubic miles)
      b. Columbia river lava flows (100,000 cubic miles) have been lifted at least 10 miles; (calculate work, power and horsepower if over period of 10 years)
   2. Energy released in diastrophism
      a. Broad uplift (Grand Canyon as an example)
      b. Folds
      c. Earthquakes
   3. Energy released down geothermal gradient
F. Balance sheet of earth energy
   1. External energy—degradational
   2. Internal energy—aggradational

LECTURE 19 CYCLES OF MATTER TRANSFER IN THE EARTH

A. Products of geological processes: erosional and depositional land forms, rocks
   1. Size, shape and sorting of grain particles of deposits a clue to energy relationships of distant past
      a. Large particles only are deposited where there is a high level of kinetic energy; small particles only where there is a low kinetic energy level (rapid stream compared with sluggish one)
      b. Slight range in size of deposited particles indicates a relatively low energy gradient, while a large range in size indicates a high energy gradient
      c. Interpretations: each deposit reflects the particular environment in which it was formed; present dry deposits are a clue to the kinetic energy level at the time of formation
         (1) Sand of sand dunes; low energy gradient, leaves record of velocity and direction of wind at time of deposition
         (2) Gravel beach: low energy gradient, high energy level
   2. Hutton's principle of Uniformitarianism: Hutton assumed that the rocks which we find are the result of natural forces; the same forces that are at work today
      a. What we find today is then interpreted as the result of familiar forces operating through vast periods of time
      b. Principle stimulated innumerable investigations
B. Rocks
   1. Sedimentary rocks: aggregates of material much of which has been eroded,

deposited and later uplifted; size of particles, roundness, sorting, composition and fossils all a clue to history; repeated deposition and uplift evidence of energy cycles

2. Igneous rocks: crystalline, massive
   a. Lavas: crystals 1/10 mm. or less in size, interlocking texture with no evident orientation, composed almost entirely of silicates; can observe origin of lavas today
   b. Canadian shield rock: composition and structure essentially the same as lava, coarse grained, however, shows no relation to any volcanoes
      (1) Cuts across layers of sedimentary rock which show evidence of heating
      (2) Large crystals indicate rock came into crust at great depth and cooled slowly (In laboratory crystals that develop slowly are larger)
3. Metamorphic rocks: crystalline rocks, grains oriented at right angles to pressure (In laboratory solid rocks go into solution at high temperature when extreme pressure is applied, with lessening of pressure they recrystallize with reorientation of grains), may be formed from igneous, sedimentary, or other metamorphic rock

C. Relations among the rock groups
   1. Igneous, sedimentary and metamorphic rocks can become weathered, eroded and eventually be deposited as sediments
   2. Sediments can be consolidated, uplifted, and exposed as sedimentary rock
   3. Sediments can be buried, folded and recrystallized, uplifted and exposed as metamorphic rock
   4. Perhaps sediments may be buried, melted, uplifted and exposed as igneous rock

D. The rock cycle: same materials appear repeatedly in different forms at different levels in earth's crust depending upon action of energy upon them
   1. Energy is absorbed in vast quantities in the process of folding, recrystallization and uplift
   2. Energy is lost in all degradational processes

Lecture 20 MATTER AND ENERGY THROUGH TIME ON THE EARTH

A. The concept of dynamic time—age of earth in cycles of erosion, submergence, deposition and uplift
   1. Evidence of energy cycles from stream work: streams transport and deposit material
   2. Evidence of energy cycles from sedimentary rocks: criteria and principles
      a. Principle of super position: younger rock layer is on top
      b. Principle of intrusion: intruded igneous material is younger than layers it cuts
      c. Principle of folding: if folds are truncated, rocks must have been folded, uplifted and eroded
   3. Evidence of energy cycles from unconformities—principle of unconformity: if folds are truncated and overlain by sediments, then there is evidence for a complete erosion cycle; folding, uplift, erosion, submergence, deposition, and uplift
   4. Worldwide uplifts as markers in dynamic time
      a. Factors in interpretation
         (1) There is no evidence of a beginning
         (2) Intrusions usually occur at time of folding

(3) Cycles can be correlated from place to place by fossils
b. There is evidence of at least 6 major cycles of erosion and uplift

B. Attempts to measure geologic time in years—absolute time
1. Absolute time from gradational agents
a. The depth of a gorge may be used as an index of its age by assuming
(1) Rate of application of energy same as in past
(2) Gradient decreases through time
(3) Kind of materials being cut today erode at same rate as those formerly cut
b. The thickness of a formation may be used as an index of its age by assuming the material was deposited at same rate in past that similar deposits are laid down at present
2. Absolute time from total rock column
a. Geologic column of deposits is at least 100 miles thick
b. Calculate age by assuming present rate of deposition throughout all time
3. Kelvin's prediction of the age of the earth—assumed earth to be infinitely hot, calculated 20 million years to cool to present temperature
4. Use of radioactive minerals as a clock
a. Uranium changes to lead and energy through a progressive series of changes
b. No natural conditions make any difference in the rate of breakdown
c. Can determine age of rock by determining percentage of unaltered uranium remaining
5. The minimum age of the earth
a. Oldest determined age is 1,800,000,000 years
b. Determination of age was made on rock intrusive into still older rocks

LECTURE 21 THE EARTH'S SURFACE FEATURES

A. Earth processes and the concept of change
1. Vast geologic time vs. span of human history
2. The processes that change the earth's surface
3. Destructive vs. constructive processes
4. Landforms: an expression of structure plus process plus stage (time)

B. Relation of process to structure
1. Materials of the earth's surface
a. Sedimentary rocks—bedded
b. Igneous rocks—commonly non-bedded (massive)
c. Metamorphic rocks
d. Unconsolidated surface materials on bedrock
(1) Layers of sediments deposited by streams, wind, etc.
(2) Unstratified deposits such as glacial boulder clay
(3) Soil and subsoil weathered from the bedrock beneath
2. Selective or differential erosion, nature of process
a. Forms in flat-lying strata: mesas and buttes, rock terraces, table rocks
b. Forms in inclined and folded strata: cuestas and hogbacks, parallel ridges with trellis drainage pattern
c. Forms in massive rock, such as granite: erosion domes
d. Relation of cracks or joints to the erosion processes: chemical weathering, frost weathering

C. Relation of eroded landforms to time or stage—stream erosion "cycle"
1. Valley development

2. Names of sequential stages: youth, maturity, old age
3. End of the cycle: peneplain, monadnocks

Lecture 22 PHYSICS OF THE ATMOSPHERE

A. Weather processes—interaction of energy and matter
  1. The atmosphere a heat engine
    a. Chief energy source—the sun
    b. Energy distributed as received
    c. Energy changes
    d. Trends toward equilibrium
      (1) Air movements—winds
      (2) Fall of rain
      (3) Trend to decrease of potential energy; to low temperature heat energy
  2. Relation of our weather to the atmospheric heat engine
    a. Winds—air movements
    b. Clouds and rain—due to life of heated air or to interactions of warm and cold air masses
    c. Frost or dew—due to radiation of heat energy and presence of water vapor in air

B. Atmospheric temperature
  1. Source of heat energy, the sun: solar constant, wave length
  2. What becomes of incoming radiation, greenhouse effect
  3. Comparison of solar and internal energy of earth
    a. Temperature distribution vertically: lapse rate—3.2° F./1000 ft.; vertical temperature structure of lower air; troposphere, tropopause, stratosphere
    b. Vertical temperature changes due to lift of air: temperature decrease equals adiabatic rate, 5.5° F./1000 ft., lifted air cools rapidly

C. Atmospheric moisture—from evaporation
  1. Evaporation process and latent heat-energy is required
  2. Humidity—the measure of atmospheric moisture: vapor pressure, relative humidity, absolute humidity, specific humidity
  3. Condensation of atmospheric moisture: dew point temperature
  4. Processes that cool the air and cause condensation
    a. Adiabatic processes: orographic lift, convectional lift, frontal lift (chinook wind, cumulus clouds)
    b. Radiation from air itself or from ground—ground fog
    c. Contact of warm air with cold ground—sea or advection fog
  5. Temperature—height problems
    a. 80° F. at ground. At what height freezing temperature, 32° F.?
    b. If temperature is 80° F. and dew point equals 72° F., what is height of base of cumulus clouds due to convection?

D. Atmospheric pressures and winds
  1. The cause of all winds: convection due to unequal energy distribution
  2. Differences of atmospheric pressure—correct to sea level
  3. Pressure gradients—isobars, gradient force
  4. The Coriolis force
  5. Resulting surface wind belts of earth: polar easterlies, westerlies, trades
  6. Modifications due to land and sea relationships—land heats and cools faster
    a. Monsoons of India
    b. Land and sea breezes

Lecture 23 WEATHER

A. Weather
  1. Elements
  2. Weather map
    a. Association with highs and lows
    b. Change and progression of weather in time and space
    c. Former interpretation of lows—convectional
B. Air mass theory of weather
  1. Planetary winds and calm belts—polar and tropical air, "polar front"
  2. Chief air masses affecting U.S.
  3. Air behavior at frontal surfaces: lift, adiabatic cooling
  4. A low or cyclone—what is it?
    a. Cold and warm fronts
    b. Cold and warm air masses
    c. Weather conditions near front
    d. Origin, movement, and end
  5. Sequence of conditions as low approaches, and passes
C. How the forecaster predicts weather
  1. Study of successive synoptic maps for 6 or 12 hour periods
  2. Movements of storm centers
  3. Movements of fronts—computed
  4. Predictable developments
D. Special weather types
  1. Cold wave of winter
  2. Thunderstorm of summer—convectional: stability and instability of air
  3. Tropical cyclones
    a. Location
    b. Size, winds, movement, time of year
      (1) Pressures
      (2) Effects
      (3) Location of center by Mariners' rule; 8–12 points to right of wind (North Hemisphere)
      (4) Energy source—release of latent heat

Lecture 24 WHAT IS ELECTRICITY

A. Electrostatics and magnetism from early men through the Dark Ages: hindrances to early development
  1. Natural phenomena regarded as mystical
  2. Fear of meddling in the realm of the Gods
B. The experimental age begins: rapid advance in science
  1. Work of William Gilbert (1600)
    a. Magnets: could make them from iron or nickel or cobalt by rubbing with lodestone; one pole points north; like poles repel, unlike poles attract; magnetic field of influence around a magnet (demonstrated each of these qualities)
    b. Electrostatics: Rubbed rubber with fur or flannel—found field of influence around it; effect is conducted by a copper wire, not by a dry string (Projected electroscope, demonstrating electrostatic field around rubbed rubber rod, conduction of charge by copper wire and wet string, but not by dry string)

2. Work of Franklin (time of revolutionary war): kite experiment
3. Separation of charges by chemical methods: Galvani and Volta
4. Oersted's discovery of a connecting link between magnetism and electricity

C. Discovery of a new particle—the electron
1. Cathode ray beam: material nature of the electron
   a. Particle carrying electricity is negatively charged
   b. Particle has kinetic energy, hence has mass
2. The electron is established
   a. Experiments of Thomson: determined ratio of electron charge to mass by experimenting with effects of electrostatic charges and magnetic fields upon path of electron in Crooke's tube
   b. Oil drop experiment of Millikan: determined unit of charge of electron to be 1.6×10^{-19} ampere seconds; then applying ratio established by Thompson, mass to be 1/1800 that of the hydrogen atom

D. Explanation of preceding phenomena in terms of electron activity

Lecture 25 ELECTRONS AT WORK

A. Ohm's Law: Current $(\text{amperes}) = \dfrac{\text{Potential difference (volts)}}{\text{Resistance (ohms)}}$ (demonstrated with circuit including battery, variable resistance, lamp, voltmeter and ammeter)

B. Dangers involved in handling electrical circuits

C. Heating effect of electric current (demonstrated with a heating coil)

D. Mechanical motion: electric motor a device to change electrical energy into mechanical energy by the interaction of magnetic fields

E. Electromagnetic induction (demonstrated step-up transformer, lighting of lamp attached to coil immersed in water in charging magnetic field, melting of iron wire with step-down transformer)
1. Faraday's principle; whenever there is relative motion between a conductor and a magnetic field, a current is induced in the conductor
2. Voltage of induced current depends on magnetic field intensity, the rate of motion, or the number of turns in the conductor

F. Electromagnetic waves (radio)
1. In an electric circuit, energy=amperes$\times$volts$\times$time
2. Clerk Maxwell (1865) predicted that it is possible to separate energy from an oscillating circuit
3. Hertz (1885) verified Maxwell's theory
4. Marconi (1901) sent radio waves across Atlantic

G. Freeing electrons from surfaces
1. Thermoelectric effect: removal of electrons by heat
2. Photoelectric effect: removal of electrons by light (demonstrated by flashing light on photoelectric cell which closed circuit ringing bell)

H. X-rays: produced by bombarding target with high velocity electrons

I. The electron microscope: uses electrons instead of light; refraction is by means of a magnetic field

Lecture 26 RADIOACTIVITY

A. Discovery
1. State of Physical Science at end of last century: Michelson-Velocity of light; Richards—exact atomic weights

2. Roentgen 1895: X-rays, invisible rays that could penetrate opaque objects, source other than X-ray tube?
3. Becquerel 1896: (fluorescence demonstration); possible additional source of X-rays (demonstrate set up of Becquerel's experiment), accident—sun did not shine for several days—developed plates anyway—strong image; darkness—image independent of incident light; electroscope: principle—measure of activity
4. Work of M. Curie and her husband: activity proportional to per cent of uranium, some ores peculiarly active, 4$\times$pure uranium, two new elements, polonium and radium

B. Properties of radioactive substances
1. Behavior: temperature, electric charge, light emitted, photographic effect
2. Explained on basis of rays: Rutherford, Soddy, Ramsay
3. Properties of rays: lead block experiment (table of mass, charge, velocity, ionizing power, penetrating power, nature)
4. Radium $\rightarrow$ helium: (project slide showing radioactive series)

C. Rate of radioactive disintegration
1. Concept of half life (slide)
2. Uranium series (slide), Uranium 4.67×10^{9} years, lead is final product
3. Emphasize that rate is not affected by physical or chemical conditions; geology

D. Striking experiments
1. Spinthariscope
2. C. T. R. Wilson cloud chamber

E. Brief mention of artificial radioactivity: any element now available in radioactive form, pounds can be manufactured as by product of atomic bomb or use of atomic power in industry

F. Necessary modification of concepts:
1. Element
2. Energy conservation

Lecture 27 ATOMIC STRUCTURE

A. Introduction
1. Review concept and definition of atoms, indestructible unit of an element, laws of chemical combination by weight, all of same element alike, display of pile of H_2O molecules
2. Can atom be subdivided?
If so—what are components and how are they arranged?
3. Mention already made of nucleus (diameter 10^{-13} cm.) and satellite electrons, diameter 10^{-8} cm. for atoms; nucleus is to diameter of atom as bb shot is to a football field

B. Structure of atoms
1. Atoms contain electrons; photoelectric effect, sound movies; thermionic effect—Edison-radio tubes; frictional electricity, comb hair, comb picks up electrons
2. Atoms contain protons: (nucleus of H atom); atoms are electrically neutral
3. Evidence as to arrangement
a. Particle bombardments of Rutherford, nucleus-positive, massive; measure charge, 79 for gold; atomic number, isotopes, satellite electrons
b. Periodic table, similar elements—similar structure

c. Rare gases—stable structure

d. Spectra: light emitted or absorbed, typical for each element; process similar to describing an organ from its music

e. Chemical compounds formed: LiCl, NaCl, $MgCl_2$

4. Typical arrangements: H, He, (alpha particle), Li, Na, C, F, Ne; slides of two typical families

C. Use of atomic structure

1. Review spectra: absorption, emission, explained on basis of atomic structure
2. Explain nature of chemical bond

a. Loss and gain of electrons: Na+Cl, Mg+2Cl

b. Sharing of electrons: C+H, O+H

3. Explain periodic table

D. Elaborations to include nucleus

1. Structure of nucleus: isotopes, ${}_3Li^6$ ${}_3Li^7$; protons, neutrons in nucleus
2. Transmutations (natural)

Ra→∝ alpha particle or He^{++} ion atomic weight 4 atomic number 2
Ra→Rd
atomic number 88 86
atomic weight 226 222
RaC→B *Beta particle or electron*
RaC→Radium C′
atomic number 83 84
atomic weight 214 214

3. Transmutations (artificial)

${}_5B^{10}+{}_2He^4 \rightarrow {}_7N^{13}$+neutron

E. Review nature of a theory, mental model, this morning's lecture—one convenient version of atom; elaborations are largely mathematical

Lecture 28 THE ELECTROMAGNETIC SPECTRUM

A. The electromagnetic spectrum

1. Common characteristics of its components
2. Four questions to be applied to each component

a. What are its principal characteristics?

b. How is the radiation produced?

c. How is the radiation detected?

d. In what way does it affect our lives?

B. The components of the electromagnetic spectrum

1. Visible spectrum—brief review
2. Infrared or heat waves

a. Emission limits

b. Transmission characteristics

3. Radio or Hertzian waves: the broadcasting range, television, radar
4. Induction heating
5. Ultraviolet rays: erythemal rays, the bactericidal band, transmission by glass and quartz
6. X-rays: diagnostic band, therapeutic and metal radiographic band, recent developments
7. Gamma rays
8. Secondary cosmic radiation

THE ELECTROMAGNETIC SPECTRUM

Radiation Type	Source	General Character	Wave Length	Means of Detection	Effects on Our Living
1. POWER	Low frequency oscillation of charges in electrical circuits.	Very long wave length.	Above 1 meter (may be up to several thousand miles in length).	Resonant electric circuits. Heating effects.	Industrial heating. Diathermy.
2. RADIO	High frequency oscillation of charges in electrical circuits.	Great carrying power and penetration.	From 10 kilometers to .1 cm.	Resonant electrical (radio) circuits.	Wireless communication. Entertainment.
3. INFRA-RED	Random molecular and atomic motion. Heat source.	Radiant heat.	From .05 cm. to visible red.	Thermometers.	Warmth. Necessary for the continuation of life.
4. VISIBLE LIGHT	Electron disturbance in outer orbits of atom. High temperature. Electrical excitation.	Affects retina of eye. Produces light and color effects.	From deep red .000077 cm. to violet .000040 cm.	Visual. Photographic.	Sight. Photosynthesis.
5. ULTRA VIOLET	Electron disturbance in deeper orbits of atom. Electric discharge in gases at low pressure.	Highly absorbable. Lethal and sunburn effects.	Below visible violet to 10^{-7} cm.	Photographic. Photo-electric effect.	Health factor. Bactericidal radiation.
6. X-RAYS	Electron disturbance in orbits next to nucleus. Impact high speed electrons on target.	Penetrate light opaque substances. Penetration increases with voltage.	From 10^{-6} to 10^{-9} cm.	Photographic. Ionization.	Diagnostic. Therapeutic.
7. GAMMA	Radioactivity. Disintegration of the nucleus.	Can penetrate foot of lead.	About 10^{-9} cm.	Photographic. Ionization.	Therapeutic.
8. COSMIC (Sec.)	Outer space. ?	Can penetrate several feet of lead.	Shorter than 10^{-10} cm.	Ionization.	?

LECTURE 29 THE NUCLEUS—NEW SOURCE OF ENERGY

A. The artificial disintegration of atoms
   1. Rutherford experiment (1919)
      $_2He^4 + _7N^{14} \rightarrow _8O^{17} + _1H^1$
   2. Identification of the neutron (1932)
      $_2He^4 + _2Be^9 \rightarrow _6C^{12} + _0n^1$
   3. The neutron as an effective transmitting agent
B. The equivalence of mass and energy
   1. From relativity theory. Einstein (1905)
      $E = m\,c^2$
   2. Experimental proof. Cockcroft and Walton (1932)
      $_1H^1 + _3Li^7 \rightarrow 2\ _2He^4 + 17$ Mev of KE
      1.0076 7.0165 8.0056 (figures are masses)
   3. Efficiency of process
   4. Nuclear binding energy and nuclear stability
C. Nuclear fission
   1. Discovery fission U–235 (1938)
   2. Explanation of process
   3. Possibility of chain reaction
D. Isolation methods $_{92}U^{235}$
   1. Thermal diffusion
   2. Porous barrier
   3. Centrifugal methods
   4. Electromagnetic separation
E. Production of new fission element $_{94}P_u{}^{239}$
   1. Neutron capture and electron emission
      $_{92}U^{238} + _0n^1 \rightarrow _{92}U^{239} \rightarrow _{93}Np^{239} + _{-1}e^0$
      $_{93}Np^{239} \rightarrow _{94}Pu^{239} + _{-1}e^0$
   2. Production details: the pile and controlled reaction; separation
F. The nuclear (atom) bomb
   1. Magnitude of mass-energy transformation
   2. Relative destructiveness
   3. Basic ideas
G. You and nuclear energy

LECTURE 30 NATURE OF THE SCIENTIFIC METHOD

A. Common sense and uncommon sense
   1. Common sense limited by extent of experience
   2. Common sense sometimes unreliable, particularly when applied to new situations
      a. "Light always travels in straight lines," yet a star behind the sun is visible during an eclipse of the sun
      b. "The sum of the internal angles of a triangle equals 180 degrees"
         (1) Not true at high velocity
         (2) Not true on a sphere
      c. Aristotle's views on falling bodies nearer to common sense than Galileo's
   3. Some things are beyond the range of common experience, for example
      a. The effect of extreme velocity upon mass
      b. The nature and movements of extremely small particles
B. The nature of science
   1. Built on reliable facts

2. Operational definitions are essential for experimentation: for example, the distinction between heat and temperature, or the concept of growth
3. A symbolic notation convenient to handle is essential
   a. Examples of mathematical and chemical notation
   b. Concepts of numbers held by primitive peoples
   c. Modern concept of numbers
4. Development of concepts and theories:
   a. Basis for arranging and ordering of experimental facts
   b. Useful theories suggest new experiments and predict new facts
5. Perpetual modification and extension of facts, symbols, concepts and theories; every problem that is solved must be replaced by a new puzzle: continuous extension of experience

Lecture 31 SOLUTIONS AND IONS

A. Solutions as a bridge between the physical and biological sciences
   1. Water as an important solvent
   2. Examples of various kinds of solutions
B. Properties of normal solutions
   1. Definition of terms: solvent and solute, dilute and concentrated, saturated, unsaturated, and supersaturated
   2. Changes in boiling point and freezing point of solvents
   3. Osmotic pressure
C. Nature of normal solutions: rise in boiling point, depression of freezing point and increase in osmotic pressure accounted for in terms of molecular theory
D. Ionic solutions: acids, bases, salts
   1. Abnormal effects on boiling point, freezing point, and osmotic pressure
   2. Electrical properties
      a. Demonstration of current carrying capacity of acids, bases, salts as contrasted with glycerol, sugar solution, and alcohol
      b. Distinction between electrolytes and non-electrolytes
         (1) As carriers of current
         (2) In effects upon freezing points and boiling points
E. Ionic theory
   1. Distinction between atoms and ions
   2. Explanation of properties of solutions of acids, bases and salts
      a. Electrolytes break up in water to form ions; they depress freezing point and raise boiling point more than other solutes
      b. Ions are charged particles; electrolytes conduct electricity
      c. Ions act independently; e.g., whenever Na_2CO_3 is added to either: $Cu(NO_3)_2$, $CuCl_2$, or $CuSO_4$, then $CuCO_3$ results

Lecture 32 COLLOIDS

A. Distinguishing features of colloids
   1. Optical properties—the Tyndall effect
   2. The Brownian movement
   3. Lack of diffusion
B. Types of colloids
   1. Fluid dispersions—examples
      a. Solid in liquid; gold in water
      b. Solid in gas; smoke
      c. Liquid in gas; fog

        d. Liquid in liquid; mayonnaise
    2. Rigid colloids—examples
        a. Liquids in liquid; jello
        b. Gas in solid; activated charcoal

C. Nature of colloids
    1. Position in classification of matter
    2. Size of colloid particle compared to that of bacterium, wave length of red light, molecule, atom and nucleus; also to limit of light microscope and electron microscope
    3. Immense surface area of colloidal particles
    4. Adsorptive properties as consequence of large surface area
        a. Demonstration of activated charcoal filter
        b. Principle of the gas mask
        c. Enzymes in food digestion
    5. Electrical properties as consequence of adsorptive properties
        a. The smoke precipitator demonstrated
        b. Precipitation of rubber from latex by charged particles demonstrated
        c. Precipitation of colloid by adding solution of charged ions demonstrated

D. The significance of colloids
    1. In industrial applications
    2. In biological phenomena

Lecture 33 ORGANIC CHEMISTRY

A. Historical review
    1. Work of alchemists
        a. Animal and vegetable vs. mineral
        b. Organisms→organic compounds as contrasted with inorganic
    2. Vitalism vs. mechanism: unknown and unknowable life force assumed by vitalists to account for difference between organic and inorganic compounds
    3. Wohler (1828)
        a. Made urea in the laboratory, quotation, "I must tell you that I can prepare urea without requiring a kidney or an animal, a man or a dog"
        b. N_2CH_4O—Urea and another compound, ammonium cyanate, both have the same formula
        c. *Isomers,* same number and kind of atoms, different arrangement
    4. Meaning of "organic" now

B. The nature of organic compounds
    1. Valence—different combining power of different atoms, $MgCl_2$, $NaCl$; explanations in terms of electron distribution
    2. Isomers of C_4H_{10} (show models), graphic formulae: $-\underset{|}{\overset{|}{C}}-$ $-Br$ $-Na$ $-O-$ $-H$
    3. Determination of structural formulae from experimental data (table of properties on board for two compounds having formula C_2H_6O), (models made by students of C_2H_6O), (one form contains a unique H—one out of six hydrogens replaced)
    4. Verification by synthesis $H-\underset{H}{\overset{H}{C}}-O-Na+Br-\underset{H}{\overset{H}{C}}-H \rightarrow NaBr+H-\underset{H}{\overset{H}{C}}-O-\underset{H}{\overset{H}{C}}-H$

C. Significance of organic chemistry
    1. Formulae of some typical compounds
    2. Basis for synthesis of new compounds

Lecture 34 THE CHARACTERISTICS OF LIVING THINGS

A. Kinds of living organisms—from
   1. Smallest to largest
   2. Simplest to most complex
B. Characteristics of living organisms as compared and contrasted with non-living materials
   1. Specificity of form, size, and structure
   2. Chemical composition
   3. Metabolism
   4. Growth
   5. Reproduction of own kind
   6. Irritability and response to environment
C. Organization of living organisms
   1. In respect to environment
      a. Spherical: equal contact all directions
      b. Radial: dorsal-ventral arrangement
      c. Bilateral: anterior-posterior arrangement, head end meets new environment
   2. In respect to structure and activity
      a. Cells
      b. Tissues
      c. Organs
      d. Systems of organs
      e. The complete organism
      f. Systems of organisms

Lecture 35 THE BIOLOGICAL UNITS OF STRUCTURE AND ACTIVITY

A. At a cellular level
   1. Walls and skeletons—supporting structures, non-living products of cellular activity
   2. Protoplast
      a. General nature of protoplasm: semi-solid, jelly-like, colloidal suspension, consisting largely of water, containing numerous granules or plastids
      b. Outer surface
         (1) Separated from outside by plasma membrane
         (2) All contact of cell with outside is through cell membrane
         (3) Surface area of cell is $4\pi r^2$; volume of contents $\frac{4}{3}\pi r^3$
      c. Nucleus
         (1) Denser than rest of protoplasm
         (2) Separated from remaining contents of cell by plasma membrane
B. At a possibly pre-cellular level

Lecture 36 THE ACTIVITIES OF LIVING ORGANISMS

A. Factors of the physical environment that influence activity
   1. Air
   2. Water
   3. Soil
   4. Temperature
   5. Light

6. Space and time
7. Other organisms

B. Activities of protoplasm
1. Growth
2. Irritability
3. Metabolism
4. Reproduction and life cycles

C. The scientific approach to an understanding of biological problems
1. Typical problems discussed
   a. Plasmolysis of cells
      (1) Effect of glycerin on onion epidermis cells
      (2) Effect of ether upon plasmolysis
      (3) Relationship to effect of ether upon nerve cells in anaesthesia
   b. Willow roots growing in sewer pipe
      (1) Description of experiment to determine optimum water concentration for growth of willows
      (2) Relating results of experiment to the problem
2. Aspects of the scientific approach
   a. Generality of the phenomena
   b. Results of these phenomena
   c. The experimental method

Lecture 37 RESPIRATION

A. Experiments with living things
1. Must insure that every factor but the variable one remain unchanged; need control to see that all environmental and all inherent factors remain constant
2. Demonstrated effect of germinating wheat and of growing yeast upon temperature by growing them in thermos bottles and observing influence upon temperature
   a. Controls for environmental factors
      (1) Thermos bottle with water and sugar only
      (2) Thermos bottle with water, sugar and formalin only
   b. Controls for inherent factors
      (1) Thermos bottle with germinating wheat, water, sugar and formalin
      (2) Thermos bottle with yeast, water, sugar and formalin

B. What is necessary for respiration?
1. An energy source, food
2. An oxygen source
3. An enzyme system

C. Products of respiration
1. Energy released
2. Carbon dioxide released
3. Water released

D. Respiratory equation

Lecture 38 PHOTOSYNTHESIS

A. The process
1. The role of light
   a. Starch is made in green leaves in light (demonstrated presence of starch in leaves of starch-free coleus after plants were placed in light for 24 hours; absence of starch in leaves of a similar plant that remained in the dark)

b. The synthesis of starch is at least two processes, the synthesis of sugar which requires light and the synthesis of starch which requires sugar but not light (demonstrated that starch-free coleus leaves floated in a glucose solution in the dark, synthesize starch)

2. Necessity of chlorophyll (demonstrated with starch-free, variegated coleus leaves that starch is present in just those parts of the leaf that contain chlorophyll)
3. Compounds used: carbon dioxide and water (demonstrated the necessity of carbon dioxide by testing starch-free coleus leaves that were placed in a large bottle to which carbon dioxide had been added; and others that were placed in a bottle where the carbon dioxide was removed by means of potassium hydroxide)
4. Substances formed: sugar and oxygen (demonstrated the production of oxygen by aquatic plants)
5. Energy relations: visible radiant energy : $6\ CO_2 + 6\ H_2O \xrightarrow{\text{chlorophyll}} C_6H_{12}O_6 + 6O_2$; for every 180 grams of sugar produced, 674 Calories of visible radiant energy are transformed into chemically bound energy
6. Definition: photosynthesis is an endothermal process in which sugar and oxygen are produced from carbon dioxide and water in the presence of chlorophyll

B. Chlorophylls (projected structural formula of one chlorophyll)

1. Both the chlorophylls and the "haem-" compounds consist of a ring of four pyrrol rings
2. Magnesium and iron seem to act as antagonistic catalysts in systems where chlorophylls and "haem-" compounds intervene in oxygen transfer

C. The emergence of ideas about photosynthesis

1. Successive discoveries during the latter part of the eighteenth century resulting in an understanding of the over-all nature of the process
2. Present attempts to determine the chemistry of the several steps in the process

LECTURE 39 SOURCE OF FOODS

A. Review of photosynthesis as food source

1. Energy stored by the process
2. Importance of the process

B. Sources of foods

1. For green plants
2. For non-green plants
3. For animals, including man
   a. For herbivores
   b. For carnivores
   c. For omnivores
   d. For parasites

C. Nature of foods

1. Characteristics of carbohydrates
2. Characteristics of fats
3. Characteristics of proteins

D. Synthesis of foods in plants

1. Complex sugars from simple sugars, sugar accumulation
2. Starch from simple sugars (demonstration: starch free leaf in sugar solution in dark), starch accumulation

3. Fats and oils from sugar
   a. Production of glycerin and fatty acids, then of fats and water
   b. Fat accumulation
4. Proteins from sugar
   a. The elements nitrogen, sulfur, and phosphorus
      (1) Their place in proteins
      (2) Their sources from inorganic salts
   b. Production of amino acids, to proteins and water
   c. Protein accumulation

E. Summary of accumulation of foods in plants

Lecture 40 UTILIZATION OF FOODS

A. Digestion of foods
   1. Definition and description
   2. The role of enzymes
   3. Changes in food substances
      a. Starches to simple sugars
      b. Fats to fatty acids and glycerol
      c. Proteins to amino acids
      d. Decomposition of cellulose by bacteria and fungi

B. Respiration
   1. Universality in living cells
   2. Importance of enzymes
   3. The chemical changes in respiration
      a. The use of food and oxygen
      b. The release of carbon dioxide and water
      c. The release of energy
      d. Aerobic vs. anaerobic respiration

C. Growth
   1. The nature of growth
   2. The complexity of the process

D. Assimilation
   1. The building of cell walls
   2. The building of protoplasm

E. Accumulation
   1. Review of storage in plants
   2. Accumulation of excess foods in animals

F. Biological relations of living things
   1. Similarities of processes in plants and animals
   2. Differences of processes in plants and animals
   3. A microcosm

Lecture 41 CHEMICAL REGULATION

A. The regulation of plant growth
   1. Responses of plants
      a. Examples of responses to light, gravity, length of day, temperature, moisture and minerals
      b. Response to light (demonstrated the response to light with tomato plants, one with one-sided illumination, the other with illumination from all sides; demonstrated that elongation of stem is faster in dark than in light by means of sprouting potato tubers and also with germinating corn seeds)

c. Response to gravity (demonstrated positive geotropism of primary roots and negative geotropism of stems by germinating corn seeds on wet blotting paper between glass plates held in a vertical position)

2. Growth-modifying substances
   a. Certain chemicals produce a turning response in a growing stem (demonstrated, making tomato plant turn away from light by applying naphthalene-acetic acid in lanolin, 1 part to 1600 parts, to the side of the stem tip toward the light; demonstrated, making tomato plant stem placed in a horizontal position turn toward the earth by applying naphthalene-acetic acid to the top side of the stem tip)
   b. Certain chemicals produce an inhibiting effect on the growth of axial buds (demonstrated by applying naphthalene-acetic acid to the cut stem of some bean plants where the apical buds are removed and by not applying it to others)
   c. Certain chemicals stimulate the growth of adventitious roots (demonstrated by showing some cuttings which had been placed over-night in a dilute solution of indole-butyric acid before planting, while others were placed in water before planting)
   d. Examples of other effects of growth modifying substances
3. Plant hormones
   a. An auxin produced in growing buds and leaves stimulates the elongation of growing stems and petioles, and inhibits the development of axillary buds
   b. A hormone produced in leaves initiates flower formation
   c. Adenine produced in leaves stimulates growth of young buds
   d. Vitamins B_1, B_6, and nicotinic acid, produced in leaves are essential for root growth
   e. Probably some factor produced in roots is essential for stem growth
4. Uses of growth modifying substances in agriculture: killing of weeds by growth modifying chemicals, spraying of apples to prevent their falling on ground, stimulation of roots on cuttings, breaking of dormancy period in potato tubers

B. Experimental determination of a hormone by Bayliss and Starling (1902): description of their experiments with dogs on the secretion of pancreatic juice which resulted in their discovery of the first known hormone, secretin

C. Examples of hormonal action in man
   1. Regulation of metabolism: thyroid gland and isles of Langerhans
   2. Regulation in emergencies: adrenal glands
   3. Regulation of specific bodily processes: parathyroid glands, certain pituitary hormones, the gonads

D. Examples of hormonal action among invertebrates

E. Hormones chemically the same in widely different groups

Lecture 42 THE LIFE CYCLES AND ORGANIZATION OF THE SIMPLEST ORGANISMS

A. Reproduction at a cellular level
   1. Surface-volume ratio change with increase in size
      a. Diffusion of material into cell in relation to size
      b. The physical basis of cell division
   2. Simple fission: bacteria, blue-green algae, slime mold

B. Asexual reproduction at a cellular level
  1. Typical cell structure reviewed
  2. General aspects of cell division
  3. Mitotic nuclear division
    a. Formation of chromosomes
    b. Longitudinal splitting of chromosomes
    c. The daughter chromosomes and their separation
    d. Formation of daughter nuclei
    e. Results of the process
      (1) Nuclei with parent number of chromosomes
      (2) Nuclei with same qualitative composition
    f. Some general aspects
      (1) Chromosome numbers in different species
      (2) Chromosome structure (with slides)

Lecture 43 REPRODUCTION AT A CELLULAR LEVEL

A. Sexual reproduction at a cellular level
  1. Production of gametes, like and unlike
  2. Alternation of generations (cytological)
  3. Meiotic nuclear division
    a. Longitudinal splitting of chromosomes
    b. Synapsis: apposition of homologous chromosomes
    c. Two disjunctions (separations) of homologous chromosomes
    d. Results
      (1) Nuclei with one half the parent number of chromosomes
      (2) Nuclei not necessarily of the same qualitative composition
  4. Summary of changes in chromosome numbers in mitosis and meiosis
  5. The life history of Ulothrix, with asexual and sexual reproduction
B. Reproduction at a tissue level
  1. Division in different planes
    a. Examples of division in one plane
    b. Examples of division in two planes
    c. Examples of division in three planes
  2. The results of relation to environment and food source
    a. Radial symmetry—examples
    b. Bilateral symmetry—examples
  3. Alternation of generations (cytological and morphological)
    a. Filamentous algae
    b. Obelia
    c. Moss

Lecture 44 REPRODUCTION AT THE ELEMENTARY ORGAN LEVEL

A. Among invertebrates (flat worms, round worms, and sea stars)
  1. Somatic (vegetative) parts
    a. Diffuse growth
    b. Vegetative (asexual) reproduction
    c. Regeneration
  2. Reproductive structures of gametes
    a. Spermatogenesis
    b. Oogenesis

3. Process of fertilization
4. Development from zygote to embryo

B. Reproduction among higher plants
1. Somatic (vegetative) parts
   a. Meristematic growth
   b. Vegetative (asexual) reproduction
2. Reproductive structures in flowering plants
   a. Flower structure—accessory parts
   b. Flower structure—essential parts
      (1) Male structures
      (2) Female structures
   c. The production of pollen
   d. The development of ovules
3. The dissemination of pollen
4. Fertilization
5. Development from zygote to embryo
6. Development of seeds and fruits
7. Germination of seeds

LECTURE 45 REPRODUCTION AT THE ADVANCED ORGAN LEVEL

A. Among the lower vertebrates
1. Formation of sperms
2. Formation of eggs
3. Fertilization
4. Cleavage
5. Germ layer formation
6. Differentiation

B. Among birds
1. Cleavage
2. Germ layer formation
3. Development of extra-embryonic membranes

LECTURE 46 REPRODUCTION AT THE ORGAN SYSTEM LEVEL

A. Reproduction among mammals (illustrated with slides and motion picture)
1. The male gonads, the testes
   a. Location
   b. Structure
   c. Production of sperms and hormones
2. The female gonads, the ovaries
   a. Location
   b. Structure
   c. Production of ova and hormones
3. Auxiliary reproductive structures
4. The process of fertilization
5. Cleavage
6. Germ layer formation
7. Implantation and intra-uterine development
   a. Development of extra-embryonic membranes
   b. Nourishment of embryo
   c. Periods of gestation
8. Birth
9. Parental care of offspring

B. Human reproduction
   1. The male urogenital system
   2. The female urogenital system
   3. The female menstrual cycle
   4. Fertilization
   5. Relation of embryo to maternal tissues
      a. Implantation in uterus wall
      b. Placenta formation
      c. Contact between mother and embryo
   6. The progressive development of body form in the embryo
   7. Birth

Lecture 47 VARIATIONS BETWEEN PARENT AND OFFSPRING

A. Variations between parent and offspring
   1. The role of the environment
   2. Examples of inherited characters
   3. The law of chance
   4. Ratios demonstrated:
      a. Tossing coins
      b. Green and white corn seedlings
      c. Ability to taste phenol thiourea
B. The work of Mendel
   1. Knowledge of reproduction and heredity in Mendel's time
   2. Mendel's experiments with garden peas
   3. Mendel's assumptions
   4. Mendel's conclusions concerning:
      a. Unit characters
      b. Dominance and recessiveness
      c. Segregation
      d. Mendelian ratios
   5. Applications of Mendelian principles
      a. A typical monohybrid cross
      b. A typical dihybrid cross

Lecture 48 CHROMOSOMES AND HEREDITY

A. Cytological basis for Mendelian ratios: review of meiosis
B. Modifications and extensions of Mendel's principles
   1. Incomplete dominance (blood types)
   2. Lethals
   3. Linkage and crossing over
   4. Multiple factors
   5. Mutations

Lecture 49 THE NATURE OF THE GENE AND DESIGNING NEW ORGANISMS

A. The nature of the gene
   1. Historical development of concept
   2. Experimental study of genes
      a. Work with Drosophila
      b. Use of X-rays and ultra-violet rays

B. Improving plants and animals
   1. Old style plant and animal breeding
   2. Scientific breeding
      a. Polyploidy and inbreeding
      b. Hybrid vigor: the story of hybrid seed corn
   3. The interplay of environment and heredity

LECTURE 50 THE DIVERSITY OF LIVING THINGS

A. Differences of a large order of magnitude
   1. Plants vs. animals
      a. Differences in cell structure
         (1) Nature of cell walls of plant and animal cells
         (2) Presence of chlorophyll in plants, with exceptions
      b. Differences in motility
         (1) Plants and animals in general
         (2) Sessile animals
      c. Organisms with both plant and animal characteristics, as Euglena
      d. Organisms with limited resemblances to either plants or animals, as bacteria and viruses
   2. Simple organisms vs. complex organisms
      a. Single-cell organisms
      b. Multiple-cell organisms
      c. Organisms of varying degrees of complexity (slides)
B. Differences within the levels of complexity
   1. Among plants
      a. Variation among flowering plants (slides)
      b. Varieties of corn, including albino corn (slides)
   2. Among animals
      a. Variation among beetles (slides)
      b. Differences within a species, the red-backed salamander *(Plethodon cinereous)* as an example (slides)
C. Diversity extends to all levels of complexity of all living things

LECTURE 51 CLASSIFICATION OF LIVING THINGS

A. The diversity of living things makes necessary a system of classification—the subscience of Taxonomy
   1. Man's tendency to classify all things
B. Possible systems of classification
   1. Artificial systems, classifying by arbitrary grouping
   2. Natural systems, based on similarity of fundamental structure
C. Application of the natural system to living things
   1. The hierarchy of groups of living things
      a. Going from larger groups to smaller, with the division into kingdoms and all of their subdivisions
   2. The binomial system of nomenclature
      a. John Ray and Linnaeus
      b. Use of generic and specific names
   3. Application of classification and naming systems
      a. Classification of the cottonwood tree
      b. Classification of the red-backed salamander

D. Fundamental problems of greater importance than classifying organisms
   1. How did all of the various kinds of living things arise?
   2. How do we account for the fact that living things can be arranged in a natural system of classification?
   3. How have living things become fitted to their environment?

Lecture 52 THE EVIDENCE FOR EVOLUTION FROM LIVING THINGS

A. Possible explanations of the origin of diverse forms
   1. Special creation of each kind of organism
   2. Organic evolution, the development of all living organisms from a common ancestor
      a. An explanation, to be in harmony with a scientific attitude, must be made on the basis of:
         (1) Observable facts
         (2) Plausible deductions from them in terms of known forces and laws
      b. Organic evolution the best explanation on this basis

B. Biological evidence for organic evolution of living things
   1. Evidence from comparative morphology
      a. Homologous structures, as vertebrate limbs (slide)
      b. Vestigial structures, with examples (slides)
      c. Variation within a species
   2. Evidence from comparative embryology
      a. Present organisms, primitive to modern
      b. Recapitulation in embryonic development
   3. Evidence from the study of heredity
      a. Natural and induced mutations
      b. Artificial selection and improvement of domesticated plants and animals

Lecture 53 BIOLOGICAL AND PHYSICAL CHANGE THROUGH TIME

A. From consideration of the range of living forms today, an infinite number of possibilities for the course of evolution might be postulated. Among the possibilities are:
   1. Start as complex forms, with development of simple forms
   2. Start as simple forms, with development of complex forms
   3. Start midway between simple and complex forms, progress toward both simple and complex forms

B. Material and energy changes of the past are cyclical (plot elevation of land masses against time)

C. Biological change is essentially unidirectional (plot number of kinds of organisms against time)
   1. The early invertebrates
   2. Rise and spread of fish
   3. Rise and spread of amphibia
   4. Rise and spread of reptiles
   5. Rise and spread of mammals

D. Summary of biological changes
   1. Increase in size
   2. Increase in specialization

3. Increase in numbers of kinds is rhythmic, but each successive rhythm evidences increase in numbers and increase in overall complexity
   a. Increases might be accounted for by creation of new forms or by the development of new forms
   b. Decreases might be accounted for by extinction or by a simplification of complex forms
4. Extinction or near-extinction; rise of progressive stocks
   a. History of particular groups of organisms—start with few in number simple in form, progress to many in number which vary from simple to complex, decline in number of kinds (plot number against time; amphibians, reptiles, mammals)

E. Comparison of biological and physical record (plot number of kinds of living things and average elevation of continents against time)
   1. Correspondence of low-lying lands and temperate climates with rise and spread
   2. Correspondence of mountain building and rigorous climates with extinction
   3. The "pulse of life" as a response to a changing physical environment

F. Summary: If we assume the life of the past to be like the life of today, the evidence is overwhelming that the life of today has evolved from simpler forms of the past
   1. The most complex forms become more complex through time
   2. There has been an increase in the number of the more complex forms
   3. There has been an overall increase in the number of kinds
   4. History of any related forms
      a. Start with a few simple forms
      b. Increase in number of kinds and range of complexity
      c. Decrease in number of kinds, all of the remaining ones relatively complex
   5. Close correlation between physical environment and number of forms

Lecture 54 CLIMATE

A. Factors determining climate
   1. Temperature
   2. Rainfall
   3. Latitude and altitude
   4. Land and water masses
   5. Air movements

B. Climate as a limiting factor to organisms
   1. Climate types as environmental types; broad relationships of soil, vegetation, and landforms to climate
   2. Climatic regions as barriers to migration

C. The pattern of world temperatures
   1. Tropic zone—no winter
   2. Subtropics—hot summers and mild winters
   3. Midlatitudes—hot to warm summers, cool to very cold winters
   4. Polar latitudes—cool summers or none, long cold winters

D. The pattern of world precipitation
   1. World rainfall distribution
      a. Wet regions
      b. Dry regions
      c. Importance of time of precipitation

E. The pattern of climatic types, as determined by world temperature and precipitation (Examples of each type, with characteristics of rainfall, temperature, humidity, soil and vegetation)
  1. Tropical rain forest type—tropical rain at all seasons, high temperature throughout entire year yet extremes not nearly so high as those of middle latitudes, mean daily range of temperature may be as much as 20°, mean monthly range less than 5°, dense tropical jungle
  2. Savanna type—winter and wet summer season, vegetation a park-like grouping of groves of forest surrounded with grasslands
  3. Low latitude desert and steppe types—as distance from equator increases length of dry season increases, savanna vegetation is replaced by grasslands or steppes, than by bleak deserts where annual rainfall may be less than 5 inches with rapid and severe daily changes in temperature
  4. Mediterranean type—subtropical wet and dry, winters are mild and rainy, summers hot and dry
  5. Subtropical humid type—same latitude as Mediterranean type, but located on eastern side of continents, has more abundant summer rainfall
  6. Marine west coast type—mild winter, mild summer, humid
  7. Continental humid type—hot summer, cold winter, humid
  8. Mid-latitudes desert and steppe types—differs from continental humid in annual precipitation
  9. Subarctic type, cool summer, bitter winter
  10. Tundra type—short summer season with rather high temperatures, subsoil remains frozen throughout the year, vegetation ranges from small trees and shrubs to mosses and lichens
  11. Ice cap type—monotonously cold desert

Lecture 55 THE MECHANISM OF ORGANIC EVOLUTION

A. Requirements of a satisfactory theory
  1. Must account for all known facts
  2. Must be satisfactory explanation of these facts

B. Problems to be solved by a theory of evolution
  1. The origin of the diversity of living things
  2. The determination of which new types survive
  3. The manner in which new species arise

C. Theories advanced in the past
  1. Lamarck's theory
     a. Environment produces changes in organisms
     b. These changes are transmitted to offspring
     c. History of theory and present evaluation
  2. The Darwin-Wallace theory
     a. Geometrical rate of increase available to all species, but never realized
     b. Competition for survival
     c. All known species vary in inheritable characteristics
     d. Those individuals with favorable variations survive in competition with less favored individuals
     e. Survivors produce offspring that inherit the favorable variations
     f. Present evaluation of the theory
  3. De Vries' theory
     a. Genetic basis of origin of new variations through changes in the chromosomes

D. Present theory of evolution
   1. Origin of variations through mutations
   2. The effect of natural selection
   3. Survival of some non-adaptive variations
   4. Origin of new species through isolation

LECTURE 56 INTERRELATIONS BETWEEN ORGANISMS AND ENVIRONMENT

A. Ecology: the study of organisms in relation to their complete environment
   1. General connotation: the study of organisms where they are found in nature
   2. The basic needs of organisms
      a. Food requirements
         (1) Needs of organisms capable of photosynthesis
         (2) Needs of other organisms: organic and inorganic materials
      b. Shelter requirements
         (1) Necessity of rest periods
         (2) Protection during rest
      c. Reproduction for perpetuation of race

B. Environmental influences upon organisms
   1. Physical factors
      a. Light
         (1) Its importance in photosynthesis
         (2) Photosynthesis as a food source for organisms
         (3) Various responses of organisms to light
      b. Temperature
         (1) Importance in biochemical reactions
         (2) Influence upon activities of organisms
         (3) Influence upon distribution of organisms
      c. Water
         (1) Importance in life processes
         (2) Importance as a part of the external environment
      d. Chemicals
         (1) Needed in life processes
         (2) As factors of the external environment
      e. Soils
         (1) As a habitat
         (2) As a source of water and chemicals
      f. Combinations of physical factors
         (1) The interrelations of physical factors
         (2) Importance of a single factor when it falls below the minimum needed by an organism
   2. Biological factors—the influence of other organisms
      a. Plants acting on plants
      b. Plants acting on animals
      c. Animals acting on plants
      d. Animals acting on animals

LECTURE 57 THE NATURAL COMMUNITY

A. Organisms are always dependent upon other organisms. Examples:
   1. Animals dependent upon plants
   2. Plants dependent upon animals or other plants

B. Communities may be independent of each other
   1. The community: an assemblage of organisms that is independent of other assemblages and that is self-sustaining, provided it is given radiant energy
   2. Communities that are not independent of others
C. Organization of natural communities
   1. Three major groups: terrestrial, fresh-water, and marine
   2. Zones of terrestrial communities, based on climate
      a. Tundra
      b. Coniferous forests
      c. Deciduous forests
      d. Prairies
      e. Deserts
      f. Tropical rain forests
      g. Savannas
   3. Organization within the community
      a. Horizontal and vertical stratification
      b. Food relationships
         (1) Primary dependence on photosynthesis
         (2) The pyramid of numbers
         (3) Food cycles
      c. Activity
         (1) Competition for food and space
         (2) Diurnal and nocturnal activity
D. Ecological succession
   1. Sand dune succession (illustrated with slides)
   2. The development of a climax vegetation
   3. Other successional series

LECTURE 58 DISEASE AS A BIOLOGICAL PHENOMENON

A. Levels of dependence among organisms
   1. Predators vs. parasites
      a. Criteria: size, length of time, closeness of association, number of species involved
      b. Intermediate relations
   2. Gradations of interaction between host and guest
      a. Commensalism: little harm or benefit
      b. Symbiosis: obligate (termites and protozoa), facultate
      c. Parasitism: obligate, facultate
B. Basis of disease
   1. General nature of disease
   2. Kinds of disease
      a. Diseases of internal origin
         (1) Deficiency diseases
         (2) Functional diseases
      b. Diseases of external origin
         (1) Infectious diseases
         (2) Diseases produced by inanimate agents

3. The biological problems of disease
    a. The story of malaria as an example

C. Germ theory of infectious diseases
    1. Historical concepts of the source of contagion
        a. Demonic theory
        b. "Wrath of God" theory
        c. "Environmental influences" theory
        d. Germ theory
    2. The proof of the germ theory
        a. The question of spontaneous generation
            (1) Work of Redi, Spallanzani, Pasteur, and others
        b. The discovery of specific disease germs
            (1) The work Pasteur and Koch
        c. "Koch's Postulates" as the basis for establishing the cause of a given disease

Lecture 59 MAN'S PLACE IN THE NATURAL WORLD

A. Biological classification of man
    1. Phylum: Chordata (Vertebrates)
    2. Class: Mammalia
    3. Order: Primates
    4. Family: Hominidae
    5. Genus and species: *Homo sapiens*
    6. The distinguishing characters of each group

B. Evidence of man's animal origin
    1. Anatomical evidence
        a. Basic structures
        b. Vestigial structures
    2. Embryological evidence
    3. Paleontological evidence
        a. Java Ape Man
        b. Peking Man
        c. Piltdown Man
        d. Heidelberg Man
        e. Neanderthal Man
        f. Cro-Magnon Man

C. Some unique characteristics of man
    1. Present biological dominance
    2. Extreme variability within the species
    3. Abnormally slow rate of development
    4. Two structures contributing to man's supremacy
        a. The hand
        b. The brain

D. The problem of man's future
    1. The progress made through science
    2. The greatest need: a scientific social basis for civilization

LABORATORY I

Measurement—Triangulation

Problem: To measure, indirectly, the distance to an object (or its size) by three different methods of triangulation.

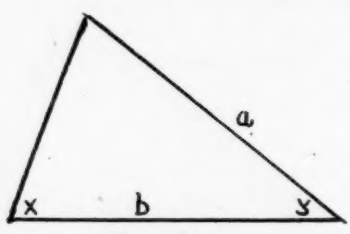
Apparatus: Cross-staff, meter stick, protractors, graph paper, hard pencil, distant objects.

Theory: If the unknown distance to an inaccessible object can be made one side of a triangle of which one other side and the included angles are known a complete triangle can be created. Then using simple principles of geometry or trigonometry the distance to the inaccessible object can be calculated. This method is regularly used by land surveyors in determining distances across rivers or to remote mountain peaks and by astronomers to determine the distances to the planets and many stars.

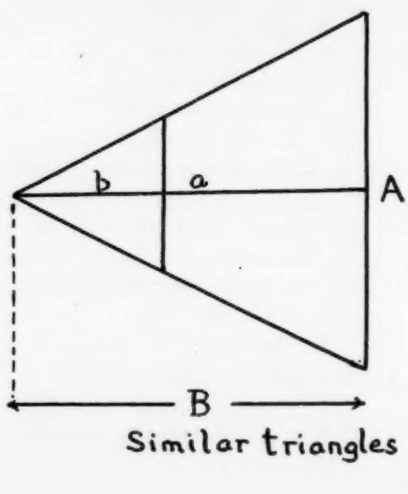
The geometric—graphic—method requires the drawing of a triangle to a known scale using the two measured angles, x and y, and the included side b (the base-line) representing the known length. The unknown length is determined by direct graphic measurement.

The trigonometric method requires the drawing of a right-angle triangle with the known base-line, known as "b," as one side of the right angle. The unknown distance becomes the other side of the right angle and is known as "a." The known angle x is opposite side "a." The length of the line "a" is then determined by the formula $\frac{a}{b} = \tan x$, or $a = b \tan x$.

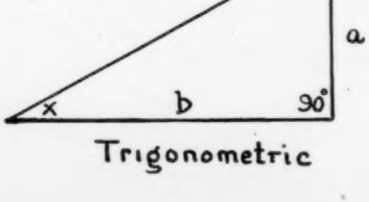
The geometric—similar triangles—method requires the drawing of two superimposed similar triangles with one angle common to both triangles. If two sides of the small triangle, a and b, and one corresponding side of the large triangle, B, are known the length of the side A of the unknown triangle may be calculated, by the simple formula of proportions, $A : B = a : b$. Therefore, $A = \frac{Ba}{b}$.



Graphic



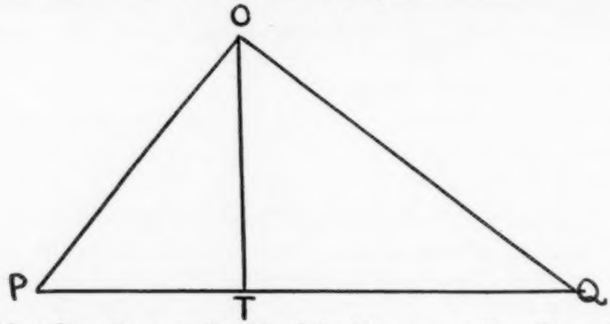
Similar triangles



Trigonometric

Experiment I—Geometric—Graphic Method

A typical land triangulation problem is represented by the geometric diagram below in which O is the inaccessible object and T is your position as the observer. The unknown distance OT is to be found by graphic methods.

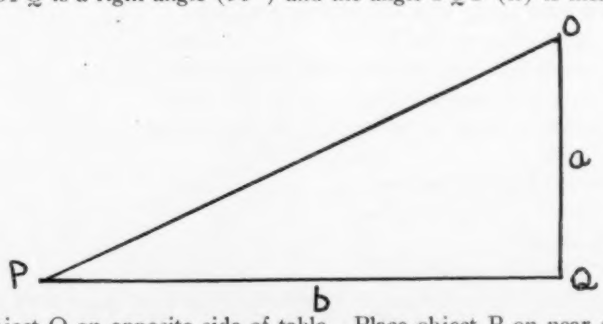


Place object O on the opposite side of the laboratory table. Place objects P, T, and Q along the near side of table in a straight line (not less than 80 cms.) approximately as shown in diagram.

1. Measure distance between P and Q............................cms.
2. Measure with protractor angle OPQ............................degrees
3. Measure with protractor angle PQO............................degrees
4. With protractor place object T so that OTQ is a right angle.
5. On graph paper draw line PQ to established scale.
6. With protractor lay off angles OPQ and PQO as measured in 2 and 3 above.
7. Draw complete triangle.
8. Drop a perpendicular from point O to T. This line on the graph paper measures .... division which is equivalent to .... cms.
9. Actual measurement of OT is .... cms.
10. Error .... cms.
11. % error is found by dividing difference between 8 and 9 above by the actual measurement. It is ....%.
12. Lists probable reasons for error.

Experiment II—Trigonometric Method

A simple land or astronomical triangulation problem is represented by the trigonometric diagram below, in which O is the inaccessible object and P and Q are your positions as the observer. The unknown distance OP (a) is to be found by trigonometric calculations, using the known distance PQ as the base-line (b). The angle OPQ is a right angle (90°) and the angle PQO (x) is measured.



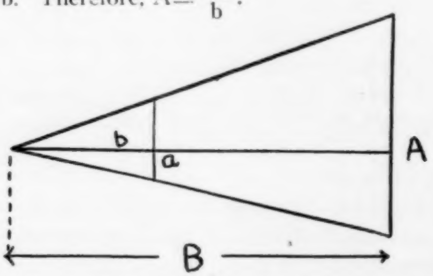
Place object O on opposite side of table. Place object P on near side of table opposite O. At the point P lay off the direction of the line PQ with your protractor

so that the angle OPQ is 90°. About 80 to 90 cms. from P, to the right, place object Q on the base-line sighted with your protractor.

1. Measure angle PQO (x) with protractor by placing base-line of protractor along line QP and move indicator arm to be in line with QP.
2. Measure accurately line PQ ....cm. .... degrees
3. The distance a is then calculated using the trig formula .... This equals ....cms.
4. Actual measurement of OP equals ....cms.
5. Error ....cms.
6. % error ....
7. Reasons for error.

Experiment III—Geometric—Similar Triangles—Method

A simple land triangulation problem for determining the height or distance of remote objects, using a cross-staff, is represented by the diagram below, in which (a) represents the cross-arm of the cross-staff and (b) the distance along the cross-staff rod from the eye to cross-arm. (A) is the height of the remote object and (B) is the distance from eye to object. In the diagram are two similar triangles in which A : B as a : b. Therefore, $A = \frac{Ba}{b}$.

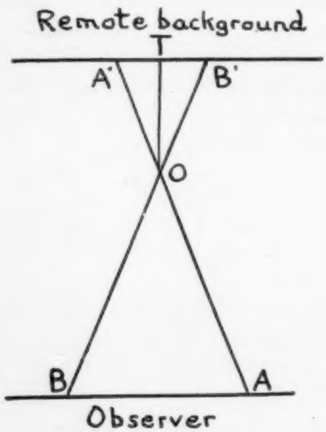


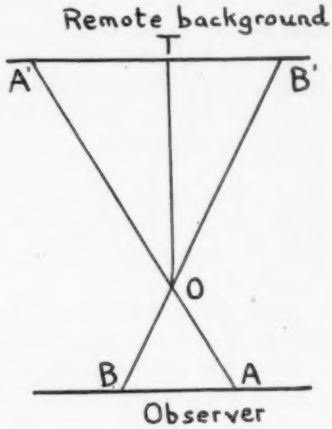
1. Mark the point P on the floor with a chalk line, then locate point Q from 3 to 5 meters from P. Mark with chalk line.
2. Ask your lab partner to stand on chalk line Q facing you.
3. Place yourself on chalk line P facing partner.
4. With end of cross-staff rod held close to your eye move cross-arm away from you until top and bottom of cross-arm is in line with head and feet of partner. (For best results be seated in a chair if possible when making this measurement.) In either case, the eye-end of the cross-staff rod should be over your chalk line. When cross-arm exactly covers your partner from head to foot, lock cross-arm in position.
5. Make the following measurements:
   (1) Length of cross-arm (a) ....cms.
   (2) Length from eye-end to center of cross-arm (b) ....cms.
   (3) Distance to partner (B) ....cms.
   (4) Calculate height of partner (A) using formula ....
   Height ....cms.
   (5) Actual height of partner ....cms.
   (6) Error ....cms.
   (7) % error ....
   (8) Reasons for error.

If there is time, repeat the above experiment, changing place with your partner and using a different length for (B).

Problem: To observe the parallax or apparent shift of a distant object against a more remote background when an observer views the object from two widely separated positions.

Also to note the variation in parallax angle as an object is viewed at various distances from an observer, as shown in the two diagrams below:

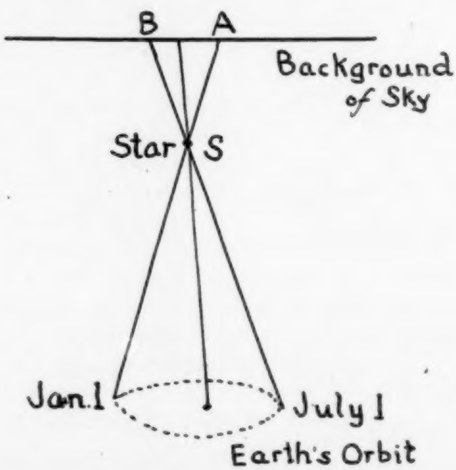




Apparatus: Meter stick, object, sight, paper.

Theory: It is a fact, familiar to everyone, that when an observer is in motion, nearby objects shift across his line of sight faster than remote objects. Thus, the telegraph poles viewed from a moving train appear to travel backward faster than the trees or buildings near the horizon.

This effect is observed also by astronomers on a much smaller scale when they view the positions of the stars. As the earth annually moves about the sun, it travels a nearly circular orbit that is 186,000,000 miles in diameter. On July 1, for example, the earth is 186,000,000 miles diametrically opposite its January 1st position, as shown in the diagram below:



If the star S is viewed on January 1st, its position against the more remote background stars of the sky appears to be at A. On July 1st, due to the change of the position of the earth in its orbit, the star S now appears to be at B. The shift from A to B is stated as the angle BSA, measured in fractions of a degree. Since even the nearest stars are very far from the earth, their angle of shift (parallax) is extremely small, and must be measured with precision using the finest astronomical equipment. The nearest star is so far away that the total angle BSA is about 1½ seconds. To draw such a triangle, using a one-inch circle for the earth's orbit, would require a piece of paper over one mile in length. All other stars have smaller parallax angles. Most of them are too far away for their distances to be measured by this triangulation method. In astronomical measurements of parallax, one half of the angle BSA is called the "heliocentric parallax."

Experiment I

For the remote background, place meter stick on edge, with the gradations visible, across your line of sight. Set the object about 30 cms. in front of midpoint of meter stick.

Along the base line BA, on your side of the laboratory table, mark in chalk the positions B and A at approximately equal distances at left and right of object.

Now sight from A to object and note meter stick reading at A′. Do the same at B and note readings below: (See first two diagrams.)

Position A—Reading of A′ ....cm.

Position B—Reading of B′ ....cm.

Difference is ....cm.

Distance A′ to T is ½ of ....cm. or ....cm.

Distance T to O is ....cm.

Tangent of angle A′OT is $\frac{A'T}{TO}$ or .... $\frac{\text{cm.}}{\text{cm.}}$ =............

Therefore parallax angle is ....degrees.

Experiment II

Repeat the above experiment, using exactly the same positions A and B, but move object O about 10 cm. from background of meter stick.

Position A—Reading of A′ ....cm.

Position B—Reading of B′ ....cm.

Difference is ....cm.

Distance A′ to T is ½ of ....cm. or ....cm.

Distance T to O is ....cm.

Tangent of angle A′OT is $\frac{A'T}{TO}$ or .... $\frac{\text{cm.}}{\text{cm.}}$ =............

Therefore parallax angle is ....degrees.

LABORATORY II

The Law of Gases

CHARLES LAW *

Problems: (1) To verify Charles Law by noting the changes in the pressure exerted by a confined gas, when it is subjected to variations in temperature. (2) To confirm, graphically, from the above test, the position of Absolute Zero on the Centigrade thermometer scale.

Theory: Charles Law states that if the volume of a confined gas is kept constant, its pressure will vary directly as its *absolute* temperature. (Absolute temperature=Centigrade temperature plus 273 degrees or T=C plus 273.) Charles Law may therefore be stated as follows:

$\frac{P_1}{T_1}=\frac{P_2}{T_2}$ in which P_1 and P_2 are the gas pressures respectively at absolute temperatures T_1 and T_2.

Absolute Zero is the point on the temperature scale at which all molecular motion has stopped. At this point the pressure exerted by the gas would also drop to zero. Therefore, when plotting the pressure-temperature readings of a Charles Law experiment on graph paper it is possible to extend (extrapolate) downward the curve connecting the points until it reaches 0 pressure. The corresponding temperature reading is Absolute Zero or $-273°$ C.

Experiment: Charles Law

Method: A quantity of air is enclosed in a stoppered flask to which is attached a mercury U-tube manometer for measuring the pressure of the gas. The flask is then heated gradually in a water bath, and the manometer readings are recorded as the water temperature increases. A graph is drawn, plotting manometer readings against temperature (Centigrade).

(Draw sketch of apparatus here)

Procedure: Submerge the open flask in a beaker of cold water for several minutes. Allow only the neck of the flask to extend above the water. Then attach the manometer tube to the flask and see that the mercury columns are level. Note the temperature of the water bath. Since the flask has a thin wall the temperature of the confined gas will always be the same as the temperature of the water bath. Also note the reading of the barometer, because the pressure of the confined gas in the flask will, at the start of the test, be the same as the atmospheric pressure in the laboratory. Record the temperature and pressure readings.

After noting the temperature in degrees C. and the manometer reading in millimeters at the start of the test, begin to heat the water bath with a Bunsen burner. (Be sure there is an asbestos wire gauze pad under the beaker.) Raise the temperature of the water to about 22° C., remove the burner, and allow the apparatus to stand 2 minutes. This will allow the air temperature in flask to equal that of the water. Let your lab partner watch the thermometer while you watch the mercury columns of the manometer. Note the difference in level between the two columns as measured in millimeters when your lab partner calls the temperature. Record temperature and pressure readings in table below.

Now repeat the heating process until the water bath is about 42° C. Remove the burner and proceed as you did for the previous readings.

* Adapted from "Experiments in General Chemistry" by Prof. Pierce W. Selwood.

Repeat for about 62°, 82°, etc., until the water boils. At the highest temperature, simply let the water boil gently for three minutes to obtain equilibrium. You should, with this procedure, get about five comparative readings of temperature and pressure, all noted in the columns below.

Temp. ° C.	Manometer Readings			Barometer	Total Gas Pressure	
	Left mm.	Right mm.	Diff. mm.	mm.	Millimeters mm.	Grams per sq. cm.* gm./sq. cm.
....	....	....	....	....	....	....
....	....	....	....	....	....	....
....	....	....	....	....	....	....
....	....	....	....	....	....	....
....	....	....	....	....	....	....

Using graph paper, plot the above test figures (Temperature ° C. and pressure in grams per sq. cm. (See model graph on bulletin board.)

* *To convert Pressure in Millimeters to Pressure in Grams/SQ. CM.*

1. Change millimeters to centimeters by dividing by 10.
2. If the columns in the manometer and barometer were filled with water you would multiply the height of the column in cm. by 1 gram, since water exerts a pressure of 1 gram per sq. cm. Your columns contain mercury which is 13.6 times as heavy as water (its relative density). Therefore, the pressure of a column of mercury will be 13.6 that of the same height of H_2O.
3. Therefore, your conversion will be: height of column in cm. times 1 gram times 13.6 (relative density of mercury) = pressure in grams per sq. cm.
4. If you wish to convert this to pounds per sq. inch do as follows: pressure in grams/sq. cm. times $(2.54)^2$ divided by 453.6 grams.

Questions

1. What form of curve do you get plotting temperature and pressure readings?

2. Extend curve beyond the lowest temperature reading you made in the experiment to the pressure axis.

At what temperature do you come to zero pressure?

3. This method of obtaining Absolute Zero is called extrapolation. In your own words, and based on the experimental procedure, write a definition of extrapolation.

4. From the form of the curve obtained, what conclusions may be drawn about the relationship of absolute temperature and pressure?

5. Do you know why Absolute temperature (symbol may be T, A, or K) is used rather than Centigrade? How was the Absolute scale derived? Why do we add the number 273 to the Centigrade scale to obtain the Absolute scale readings?

6. If you obtained a perfect value for Absolute Zero it was fortuitous. Suggest possible reasons for the deviation of your value from the accepted one.

7. Why is the boiling point of water the highest temperature you can obtain in this particular experiment (assuming the water in bath does not all boil away)?

8. Write a *short* discussion of the reasons for the temperature-pressure relationship experimentally obtained above and the meaning of Absolute Zero. Use the Kinetic-Molecular theory of matter as a basis for this discussion.

LABORATORY III

Identification of Unknowns

Purpose: The identification of some unknown substances by means of their characteristic chemical reactions.

Procedure: Label five small test tubes and quarter-fill each tube with one of the following five substances: magnesite, iron sulfide, charcoal, saltpeter, and table salt. These may be found on the side shelf. In obtaining solids from reagent bottles remove the stopper or cap, *carefully* shake out the desired amount on to a piece of clean paper and transfer the solid to the test tube. *Never stick fingers into the bottle. Never return to the bottle any material that has once been removed.*

Several chemical tests will be performed now on these five substances, and the information so obtained will be used in the identification of unknowns.

Test I

Place in a clean test tube a portion of magnesite *about the size of a pea.* Add about 10 cc. of *distilled* water. The location of the distilled water will be pointed out by your instructor. Place a thumb over the open end of the tube and shake the test tube thoroughly. If the solid seems to be disappearing or dissolving in the water continue shaking until you are convinced that the magnesite is either soluble (dissolves) or insoluble in water. Solution is said to have occurred when the mixture becomes transparent although it may remain colored.

Repeat this test with each of the four other substances.

Record your results by listing each substance in the proper column below:

Soluble in water	Insoluble in water

(Space left here.)

Test II

To clear solution of each of the substances which dissolved in water add 1 cc. of silver nitrate ($AgNO_3$) solution, and note whether a white precipitate appears. *Note:* Silver nitrate will leave a permanent stain on clothing and will discolor your hands for a short time. Handle it with care.

Record your results in tabular form on next page.

Substance	Observation

(Space left here.)

Test III

Half-fill a clean test tube with dilute sulfuric acid (H_2SO_4). Observe the color of a piece of litmus paper dipped into the acid. Color? ....

To small fresh portions of each of the substances which did *not* dissolve in water add about 2 cc. of dilute sulfuric acid. *Handle the acid with extra care so that none gets on your skin or clothing.* Should acid be spilled accidentally wash it off immediately with cold water.

Notice the evolution of any gas from the acidified sample. *Important:* If gas is evolved, smell it cautiously. In testing the odor of vapors first try wafting a little of the vapor toward the nose by waving the hand over the end of the test tube. Smell the vapors using very short breaths. *Do not inhale any gases.* Many are irritating, some are dangerous. In order to prevent obnoxious vapors from polluting the laboratory air, it may be necessary to open a window.

Record your results in a tabular form you consider suitable.

(Space left here.)

Summary of Tests I, II, III

Summarize all operations and observations up to this point by means of the following table:

Test	$MgCO_3$ Magnesite	C Charcoal	FeS Iron Sulfide	$NaNO_3$ Saltpeter	NaCl Table Salt
a. Color					
b. Solubility in water					
c. Silver nitrate					
d. Effect of acid					

Test IV

Ask for two "simple" unknowns each of which may be any of the five substances studied. Test each one by the methods outlined above. Record tests, observations, and conclusions in tabular form as indicated on last page of this experiment.

Test V

Obtain two "resemblance" unknowns. Each will be a substance which resembles one of the five substances studied. Determine which substance it most closely resembles on the basis of the tests performed. Do not be misled by superficial resemblances. Record your results on last page.

Please clean off the top of your desk with water with the aid of the counter brush. See that all bits of paper, glass, and spilled solids are placed in the *waste jar* and all liquids in the sink.

Questions

1. Define: (a) physical change, (b) chemical change.
2. Which of the above occurred in Test I? Explain.
3. Which of the above occurred in Test II? Explain.
4. Write chemical equations for those changes which occurred in II.
   Valences: Na, NO_3, Cl, Ag, H—1.
   Mg, CO_3, Fe, S, SO_4—2.
   C—4.
5. Do the same for Test III.
6. What general conclusions can you draw from this experiment?

Unknown number.... ....

Test	Observation	Conclusions

(Space left here.)

Unknown number....................

(Space left here.)

Unknown number....................

(Space left here.)

Unknown number....................

(Space left here.)

LABORATORY IV

Spectrum Analysis

Problems: (1) To distinguish between various elements by observing the individual characteristics of their bright line spectra with a grating spectrometer. (2) To determine and record the relative positions of the bright lines of a spectrum and establish their wave-lengths in centimeters.

Apparatus: Simple spectrometer with a horizontal circular degree scale, pivoted telescope with cross-hairs, diffraction grating, adjustable slit, and light sources.

Theory: The spectrum is the band of colors (violet, indigo, blue, green, yellow, orange, and red) which is produced when white light is spread out by passing it through a glass prism or ruled grating. The light from a white-hot solid, like an electric light filament, or an incandescent gas will make a continuous band of spectrum colors. But when single elements like sodium, iron, hydrogen, etc., are heated to high temperatures with a flame or electric arc the light they emit does not produce a continuous band of colors but only narrow parallel segments of color. They are, in fact, bright lines, and hence the spectra of the elements are called "bright line spectra."

Every element produces a distinctive combination of bright lines, each peculiar to itself and not duplicated by any other element just as each person has his distinctive finger print pattern. Therefore, it is possible to identify an element by producing its bright line spectrum and comparing it with a standard chart of the spectra of all elements. From a study of various spectra we may obtain much scientific information. We have learned the composition of the sun and stars, the distances to many stars, and their absolute brightness. We can detect impurities in materials too minute to be detected by chemical analysis. We have also learned much about the structure of atoms through spectrum studies.

Experiment I—To produce and observe a continuous spectrum

1. Adjustment of spectrometer.
   Set incandescent light source behind the slit of spectrometer.
   Adjust the spectrometer as instructed.
   Set the telescope arm in line with the slit.
   The vernier indicator should read approximately 360° because the slit is set at 180°.
   Adjust the slit for a sharp image.
2. Observation of a continuous spectrum.
   Move the telescope arm slowly to the right until the violet band appears.
   (a) Note the starting point of the band of violet on the degree scale. .... degrees.
   (b) Continue to move the arm noting the succession of colors until you reach the red band. Note the midpoint of the violet, green, yellow, and red bands on the degree scale.
   V........°, G........°, Y........°, R........°
   (c) Note the end point of the red band on the degree scale. ....°

Experiment II—Observation and recording of three bright line spectra

Part A

1. Set bunsen burner behind light source. See example on demonstration desk.
2. Set telescope-covered metal rod into solution. Note the element in the solu-

tion as indicated on label. Each bottle of solution will have its own metal rod. *Do not interchange these rods.*

4. Place asbestos tip into flame of burner and note the bright light of the slit through the telescope eye-piece.
5. Move telescope arm to right until telescope indicator is at the point of the degree scale which marked the beginning of the continuous spectrum.

   Now, looking through the eye-piece, move telescope arm slowly to the right and watch for bright lines, until telescope arm reaches the point on the the degree scale which marked the red end of the continuous spectrum. Between the starting point and end point may be one or more vertical bright lines in any color from violet to red. Note their positions on the degree scale and record them below.

Parts B and C

Repeat this test for two other elements and record the positions of their bright lines below.

Element		Bright Lines			
Letter	Name	No.	Color	Angle	Wave Length *
		1st			
A		2nd			
		3rd			
		4th			
		1st			
B		2nd			
		3rd			
		4th			
		1st			
C		2nd			
		3rd			
		4th			

Note: To calculate wave length:
Wave length equals number of lines per cm. on grating times the sine of the measured angle.
Grating number will be inches. Multiply by 2.54 to obtain cm.

Experiment III—Identification of unknown elements by spectrum analysis

1. Obtain from instructor a solution of two unknown elements.
2. Proceed to determine the right line spectrum of the unknown mixture by following the same procedure as outlined for Experiment II.
3. Record results below.

Solution #.............

Bright Lines			Found in spectrum of element indicated below
No.	Color	Angle	
1			
2			
3			
4			
5			

LABORATORY V

METEOROLOGY

Problem: To determine the changes in temperature which occur in air masses as they rise above the earth's surface, and the effect of moisture condensation on the rate of temperature change.

Theory: When a volume of gas is allowed to expand and no heat is added to or taken from it, the gas will cool as it expands. This effect is called adiabatic cooling. Rising air masses cool in this manner at a definite rate. The rising air mass will cool 5.5° F. for every 1000 feet of rise, until the moisture condensation level is reached. This is called the Dry Adiabatic rate.

When the air mass reaches the condensation temperature the condensing moisture gives up heat to the air. This retards the cooling rate of the air and its temperature falls more slowly as the air mass rises. This slower rate is called the Wet Adiabatic rate and is 3.2° F. per 1000 feet of rise.

Descending air will warm at the Dry Adiabatic rate.

Experiment

Moist air at zero elevation with a temperature of 65° F. is blown over a mountain 11,000 feet high. Condensation begins and clouds form at the 3,000 ft. level. Most of the moisture falls as rain by the time the air reaches the 11,000 ft. level. Now devoid of most of its moisture, it descends to the original level on the other side of the mountain.

You are to determine the temperature of the rising air:

a. At the condensation level;

b. At the top of the mountain;

and the temperature of the descending air

c. At the base of the mountain on the opposite side.

Graphic Solution

Plot the above conditions on a temperature-height diagram. Temperature will be plotted on the x-axis, increasing to the right, and height will be plotted on the y-axis.

Scale: .... divisions equals .... degrees F.

.... divisions equals .... feet height.

Plot the original temperature. Draw the Dry Adiabatic line to the 3,000 ft. level. Above that draw the Wet Adiabatic line to the 11,000 ft. level. Then draw the appropriate line to show the temperature of the descending air, to ground level.

From your graph determine the following:

a. Temperature of rising air at 3,000 ft. level ....

b. Temperature or rising air at 6,000 ft. level ....

c. Temperature of rising air at 11,000 ft. level............

d. Temperature of descending air at 5,000 ft. level ....

e. Temperature of descending air at ground level ....

Computed Solution

Below the saturation level, the air temperature (T_2) at the height H_1 will be the temperature at ground level, (T_1) minus the result of multiplying the height in thousands of feet (i.e., $H_1/1000$) times the dry adiabatic rate.

a. Write this as an equation.

b. Substitute actual values for T_1 and H_1 and solve for T_2.

(Space left here.)

Above the saturation level, the air temperature will be T_2 at height H_1 minus additional height in thousands of feet times the wet adiabatic rate.

a. Substitute actual values in equation and solve for T_3, temperature at top of mountain.

(Space left here.)

The temperature of the descending air at the base of the mountain on the opposite side will be the temperature at the top (T_3) plus the descent in thousands of feet times the dry adiabatic rate.

a. Substitute actual values and compute for T_4.

RELATIVE HUMIDITY, PER CENT

(Barometric pressure, 30.00 inches)

Air Temp.	Depression of Wet-bulb Thermometer													
° F.	1	2	3	4	6	8	10	12	14	16	18	20	25	30
0	67	33	1											
5	73	46	20											
10	78	56	34	13										
15	82	64	46	29										
20	85	70	55	40	12									
25	87	74	62	49	25	1								
30	89	78	67	56	36	16								
35	91	81	72	63	45	27	10							
40	92	83	75	68	52	37	22	7						
45	93	86	78	71	57	44	31	18	6					
50	93	37	80	74	61	49	38	27	16	5				
55	94	88	82	76	65	54	43	33	23	14	5			
60	94	89	83	78	68	58	48	39	30	21	13	5		
65	95	90	85	80	70	61	52	44	35	27	20	12		
70	95	90	86	81	72	64	55	48	40	33	25	19	3	
75	96	91	86	82	74	66	58	51	44	37	30	24	9	
80	96	91	87	83	75	68	61	54	47	41	35	29	15	3
85	96	92	88	84	76	70	63	56	50	44	38	32	20	8
90	96	92	89	85	78	71	65	58	52	47	41	36	24	13
95	96	93	89	86	79	72	66	60	54	49	44	38	27	17
100	96	93	89	86	80	73	68	62	56	51	46	41	30	21

LABORATORY VI

Electric Circuits

Problem: To set up various forms of electric circuits, using incandescent lamps in series and parallel arrangements, and to measure voltage drops and currents for calculating the component and combined resistances of each type of circuit.

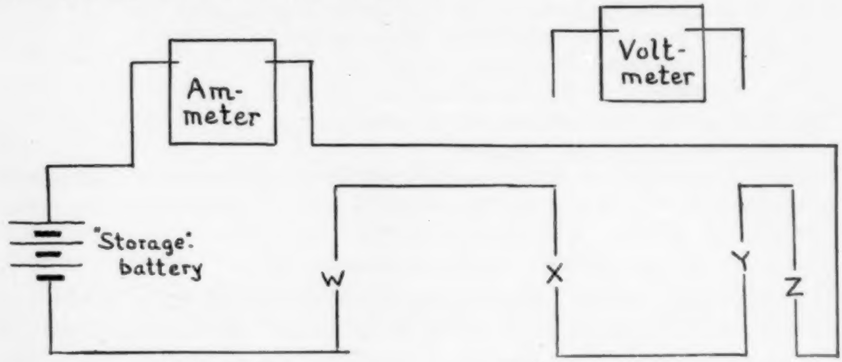
Apparatus: Lamp socket board with four identical miniature lamps (Mazda # 46, 6–8v; 0.25 Amp.) and sockets which may be interconnected in various circuit arrangements, rheostat, d-c voltmeter, d-c ammeter, storage battery, and cables.

Theory: The filament of an incandescent lamp is a resistor which becomes heated and emits a bright light when connected to a battery. The filament resistance of the lamp changes with its temperature, and can be calculated by applying Ohm's Law:

$$\frac{\text{Volts}}{\text{Amperes}} = \text{Resistance (Ohms)}$$

Experiment I—Series Circuit

Connect lamps and meters progressively in series, adding one lamp for each new test, using groupings below. Read voltage and current as indicated and calculate corresponding lamp and circuit resistances.

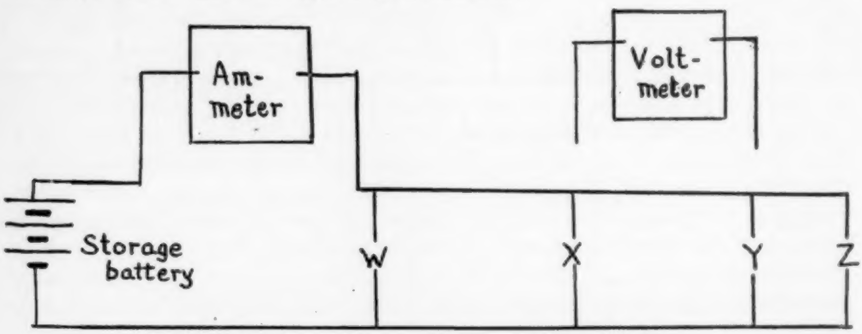


Lamps in Series	Voltage Drop: Lamp W	Voltage Drop: All Lamps	Current Amperes	Resistance—Ohms: Lamp W	Resistance—Ohms: All Lamps	Illumination of Lamp W
W	....	....	....	....	....	....
W X	....	....	....	....	....	....
W X Y	....	....	....	....	....	....
W X Y Z	....	....	....	....	....	....

Remove lamp Z from circuit and tell what happens.

Experiment II—Parallel Circuit

Connect lamps and meters progressively in parallel, adding one lamp for each new test, using the groupings illustrated below. Read voltage and current as indicated and calculate corresponding resistances.



Lamps in Parallel	Voltage Drop: Lamp W	Voltage Drop: All Lamps	Current Amperes	Resistance—Ohms: Lamp W	Resistance—Ohms: All Lamps	Illumination of Lamp W
W	....	....	....	....	....	....
W X	....	....	....	....	....	....
W X Y	....	....	....	....	....	....
W X Y Z	....	....	....	....	....	....

Remove Lamp Z from circuit and tell what happens.

* * * * * * * *

Questions

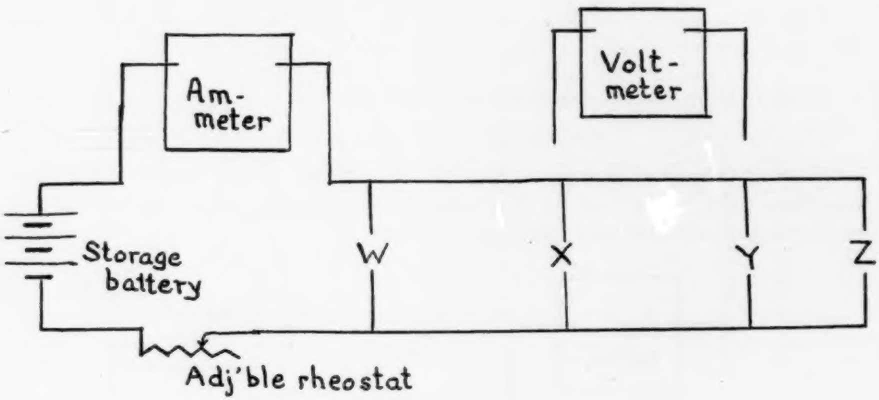
Series Circuit:

1. What happens when you remove one lamp from the circuit? Can you explain the results in terms of electric current phenomena?
2. As you add lamps to the circuit:
   a. How does the brilliance of the lamps change?
   b. How does the total current change?
   c. How does the voltage across one lamp change?
   d. How does the resistance of the circuit change?
   Explain why the above happens.

Parallel Circuit—Use the above questions for results obtained with your parallel circuit.

Experiment III—Parallel Circuit with Rheostat Control

Connect lamps, meters, and adjustable rheostat, using all lamps in each test. Turn rheostat until lamps attain maximum brilliances. Read voltage drops and current, as indicated. Then turn rheostat to ¾-position, ½-position, and ¼-position, progressively, and repeat readings. Calculate corresponding resistances of lamps and rheostat for each setting.



Rheostat Position	Voltage Drop Lamps	Voltage Drop Rheostat	Current Amperes	Resistance—Ohms Lamps	Resistance—Ohms Rheostat	Illumination of Lamps
Full Position	....	....	....	....	....	....
¾-Position	....	....	....	....	....	....
½-Position	....	....	....	....	....	....
¼-Position	....	....	....	....	....	....

Questions

1. What is the effect of the rheostat on:
   a. Brilliance of lamps?
   b. Current in circuit?
2. What is resistance range of the rheostat?
3. What are common uses of rheostats in electric circuits?

LABORATORY VII

Measurement of Respiration

Observation of Animals on Diets

Observation of Plant and Animal Species

Problems: (1) To determine the energy expended by a person, under various conditions, by measuring his oxygen consumption during a fixed interval. (2) To calculate own total energy needs for an average day, assuming one's basal metabolism to be normal. (3) To determine the effects of diets upon rat and guinea pig development by observing the differences in appearance and behavior of rats and, guinea pigs being used in diet and hormone experiments. (4) To become familiar with various species of the plant and animal kingdoms by observing representative plants and animals.

Apparatus: Respiration calorimeter, air pump, watch, weights, oxygen; experimental animals, animal scale; demonstrations of plants and animals; appendix table 12.

Theory: (1) and (2) The complex of changes which occurs within protoplasm is called metabolism. It consists of the breakdown of some compounds with a release of energy and the reverse process of building new protoplasm and tissues through the use of energy.

All living organisms carry on activities of various kinds. A few examples of animal activities are maintenance of body temperature, circulation of blood, and growth of new tissues. Energy is needed for all of these.

Energy is released when certain carbon compounds are oxidized. A definite relationship exists between the volume of oxygen needed to bring about this chemical change and the amount of energy which is released by the reaction. For instance, when 32 grams of oxygen are used in the oxidation of sugar 112 Calories of energy are released. The oxidation of carbon compounds produces the same products within the cells of organisms that it does in laboratory test tubes.

Since the direct measurement of energy released in the animal body is a laborious process, indirect means have been devised and checked in the laboratory for accuracy. It has been found, for example, that by measuring the oxygen consumed by a test individual in a given time we can calculate the energy released by him during the test interval. Each cubic centimeter of oxygen consumed, under standard conditions of temperature and pressure, is the equivalent of 0.00485 Calories. This determination assumes that the individual spends energy at the same rate as during the test period for the entire 24 hours. This figure will approximate one's total needs since it includes a considerable expenditure for activity in addition to one's basic needs. One's minimum measurable energy needs, basal metabolism, is taken from 12 to 14 hours after eating, when one is relaxed, without previous exercise.

(3) Vitamins are essential in the animal diet for maintenance of normal metabolism. A lack of one or more vitamins results in abnormal changes in both the appearance and behavior of the animal. To show this, extended experiments with a variety of diets are required. A group is maintained on a normal diet, with the necessary vitamins, while another group is fed the same diet but with the one vitamin eliminated from the food. Differences between the two groups may then be attributed to the vitamin deficiency.

Hormones are also necessary for the well being and normal development of an animal. Together with the nervous system, they integrate all the activities of the

organism. A deficiency or an excess of a particular hormone will result in some abnormality of function or appearance such as stunted or excessive growth.

(4) The plant and animal kingdoms are composed of an enormous variety of species which differ in appearance, complexity of structure, and behavior. The average person sees but a few species in his normal routine of life. A few of the less commonly known species are demonstrated in this experiment.

Experiment I—Measurement of Respiration and Calculation of Energy Cost of Activities

A—Measurement of Respiration

1. Subject, who has been sitting at rest several minutes, remains in sitting position and holds mouth piece in mouth while breathing through *his nose.*
2. Second student attaches oxygen tank hose to air inlet of apparatus and fills inside with oxygen.
3. Remove hose from oxygen tank and connect rubber hose to pump.
4. When ready to start test have subject start breathing through mouth and place nose clip to nose.
5. Third student will count time. Count the time from the first exhalation that *fails* to make the rubber top touch the stop wire.
6. As the test proceeds, keep the volume of the gas constant within the apparatus by pumping in air to replace the oxygen. Count the number of pumpfuls in the test time.
7. Fourth student calculates the amount of oxygen used. This is measured by the quantity of air pumped into the apparatus to replace the oxygen used.
8. The carbon dioxide exhaled by the subject is absorbed by soda-lime in the calorimeter.
9. Run test 3 to 5 minutes.
10. Using experimental data, fill in the table below for each test subject and calculate his Caloric needs per day. You will assume same rate of expenditure in 24 hours as occurred during respiration test.

Name of Subject	With or Without Activity	Duration of Test	No. of Pumpfuls of Oxygen (1)	Cc of Oxygen Used During Test	Cc of Oxygen Used per Minute (2)	Calories Used per Day	Body Weight lbs.	Calories per Day per Pound

(1) Each pumpful of air forced into the calorimeter replaces 90 cubic centimeters of oxygen used by the patient.

(2) Experimental results have shown that 0.00485 Calories are liberated by each cubic centimeter of oxygen consumed. To get Calories used per day from cubic centimeters of oxygen used per minute, multiply by 60 minutes in an hour, by 24 hours in a day, by 0.00485. $(60)\times(24)\times(0.00485)=7.0$. So simply multiply cubic centimeters used per minute by 7.0 and it gives the Calories used per day.

B—Calculation of own total energy needs per day.

Using the data in Table 12 of the Appendix, calculate your energy requirement for an average day of your life. Your basal energy requirement at any age above 17 years is approximately the same as it was when you were seventeen years of age for you have completed your growth.

In making an analysis of your energy requirements you will find that not all of your activities are listed in Table 12. It is necessary for you to estimate the Calories you will require per pound per hour in terms of the energy cost of a similar

TABLE 12

The Requirements and Expenditures of Energy by the Body

Average Basal Energy Metabolism of Boys and Girls in Terms of Body Weight

Age in Years	Calories Per Pound Per Day		Age in Years	Calories Per Pound Per Day	
	Boys	Girls		Boys	Girls
1	25	25	10	17	16
2	25	25	11	16	15
3	23	22	12	15	15
4	21	20	13	18	14
5	20	19	14	19	17
6	20	18	15	16	11
7	19	18	16	15	10
8	18	17	17	14	10
9	17	17			

Energy Cost of Activities

Activity	Calories Per Pound Per Hour	Activity	Calories Per Pound Per Hour
Bicycling (racing)	3.4	Sawing wood	2.6
Bicycling (moderate speed)	1.1	Sewing, hand	0.2
Carpentry, heavy	1.0	Sitting quietly	0.2
Cello-playing	0.6	Standing relaxed	0.2
Dancing, fox trot	1.7	Swimming (2 miles per hour)	3.6
Dancing, waltz	1.4	Typewriting rapidly	0.5
Dishwashing	0.5	Violin-playing	0.3
Dressing and undressing	0.3	Walking (3 miles per hour)	0.9
Eating	0.2	Walking rapidly (4 miles per hour)	1.5
Fencing	3.3	Writing	0.2
Ironing (5-pound iron)	0.5		
Playing ping-pong	2.0		
Running	3.3	Energy saved during sleep	0.05

activity listed in Table 12. Your basal energy must be calculated for 24 hours; the hours of activity and of sleep should total 24 hours. Work out your own energy requirements much as the analysis of the energy requirement of a 16 year old boy weighing 160 pounds has been worked out in the accompanying table:

ANALYSIS OF ENERGY REQUIREMENT OF A 16-YEAR-OLD BOY WEIGHING 160 POUNDS

Activities	Hours of Activity	Calories per Lb. per Hour	Calories per Lb. per Day	Pounds Body Weight	Total Expenditure per Day	Total Calories per Day
Basal requirement	24		15.0	160	2400	
Sleep (saved)	9	0.05	0.45	160	72	
Balance					2328	2328
Lying awake	1.0	0.05	0.05	160	8	
Dressing and undressing	1.0	0.3	0.3	160	48	
Eating	2.0	0.2	0.4	160	64	
Sitting	4.0	0.2	0.8	160	128	
Writing	1.0	0.2	0.2	160	32	
Standing	1.0	0.2	0.2	160	32	
Walking	1.0	0.9	0.9	160	144	
Running	0.5	3.3	1.65	160	264	
Bicycling	1.0	1.1	1.1	160	176	
Carpentry	1.0	1.0	1.0	160	160	
Walking downstairs	0.25	1.9	0.47	160	75	
Walking upstairs	0.25	6.7	1.67	160	267	
Playing pingpong	1.0	2.0	2.0	160	320	
Total cost of activities					1718	1718
Total daily requirement						4046

ANALYSIS OF OWN ENERGY REQUIREMENTS

Activities	Hours of Activity	Calories per Lb. per Hour	Calories per Lb. per Day	Pounds Body Weight	Total Expenditure per Day	Total Calories per Day
Basal requirement						
Sleep (saved)						
Balance						
(Space left here.)						
Total Cost of Activities						
Total Daily Requirement						

Questions

1. What activities are carried on at all times within the body?
2. What is a Calorie?
3. What correlation can you see between these tests and the basic diet needs of war victims and the underprivileged?
4. If fuel is not provided in the form of food where does the body obtain energy for life?
5. Distinguish between basal metabolism and total energy needs.

Experiment II—Observation of Animals on Vitamin Deficient Diets and Those Receiving Excess of Hormones, and the Control Groups

1. Weigh individual rats and guinea pigs.
   Note weights and compare with graphs.
   Be sure to return animals to proper cages.
2. Observe the condition of the animals. Appearance of eyes, of coat, irritability, personality, etc.
   Make careful notations on differences between control and experimental animals.

(Space left here.)

Experiment III—Observation of Demonstrations of Plants and Animals

Make whatever notes you wish for own use. These organisms will be discussed in lecture and discussion sections.

LABORATORY VIII

Coördination in Living Organisms

Problem: To study the structures of living organisms and the coördination of their functions.

Theory: All living organisms must have some means for acquiring food, for distributing the food to various parts of the organism, and for eliminating the waste products of metabolism. They also are capable of responding to harmful and beneficial stimuli.

The protozoa (one-celled organisms like the amoeba and paramecium) are so small that they can accumulate food and oxygen and secrete wastes directly through their surface membranes; there are no well-defined organs. Moreover, the irritability of their protoplasm causes them to respond directly to stimuli; they require no nervous systems.

When we study organisms of greater complexity (multi-cellular organisms) we find that many of the cells cannot come into direct contact with the food supply nor directly eliminate wastes. Neither are these inner cells in direct contact with

external stimuli. While the outer cells may react, the inner ones would be unable to do so. To sustain such complex organisms two additions are required: (1) a circulatory system to distribute food and eliminate wastes, and (2) a nervous system to coördinate the activities of the cells and make them operate as a coherent unit when responding to various stimuli.

A study of the various forms of animals from protozoa to vertebrates shows an increasing complexity in the coordinating structures. In the vertebrates, for example, we find highly organized organ systems for the obtaining and digesting of foods, for circulating foods and oxygen to all cells of the body, and for eliminating waste products of metabolism. There are also complex nervous systems with the control centered in the brain and spinal cord. Without these nervous systems the other organ systems could not be maintained.

Experiments and Demonstrations

I. *Living Amoeba, a protozoan. Microscope slide preparation.*

Locate an active individual under low power by carefully moving the slide.

Observe the irregular outline of the body. Note the changes in shape during locomotion and the slow movement.

The temporary finger-like projections are called pseudopodia.

Describe the way in which an amoeba moves. What is happening to the protoplasm?

II. *Reaction of Paramecium, a protozoan, to a chemical stimulus.*

Under a binocular microscope observe the rapidly moving, slipper-shaped animals.

With a pipette spread a large drop from the culture dish over the middle two-thirds of a clean slide. Place this slide against a dark background and identify the individual animals as they move around. They will appear as tiny rods.

After they become evenly distributed in the field, carefully drop *one or two small salt crystals* in the middle of the preparation. What happens?

Is Paramecium sensitive to chemical substances? Does it respond positively or negatively?

What are such responses called? Are such responses to be found in other types of organisms? List a few.

Paramecium has no nervous system. Therefore, what is the seat of control of such reactions?

III. *Capillary circulation and heart beat of the frog.*

a. Examine the microscope demonstration of circulation through the webbing of a frog's foot.
   1. What is the relative size of the blood cells and capillaries?
   2. What special relationship do capillaries bear to metabolism?

b. Observe the heartbeat in a living frog?
   1. Is the pulsation rhythmic?
   2. Do all parts beat at once?
   3. Can you distinguish between auricles and ventricle?
   What is the difference between the frog heart and the mammalian heart?

c. Study the isolated heart in the balanced salt solution.
   1. What is the source of energy for the activity?
   2. Is the heart alive?
   3. Could the frog from which the heart was removed some time ago still be alive?
   4. Define death in biological terms.

IV. *Dissections of organ systems of an embryonic pig,* to show the general body plan of a mammal.

Observe these dissections, identifying the parts of the major systems including the digestive, respiratory, excretory, reproductive, nervous, and circulatory systems. Note the various endocrine glands and their positions in the body.

Also note the interrelationship of some of the systems, namely the innervation of organs and the arteries and veins supplying the various organs.

Compare pig dissections with demonstration of rat dissection and the organ systems of the frog.

V. *Sheep brain demonstration.*

Examine the whole and half brain of a sheep. Identify the parts.

Where is the pituitary gland located?

LABORATORY IX

Reproduction and Heredity

Problems: (1) To observe various types of reproduction and reproductive structures: (a) Asexual reproduction—vegetative propagation in plants; (b) Sexual reproduction (1) Based on physiological differences, (2) Based on structural differences; (c) Mammalian structures involved in development of new individuals. (2) To identify cell structures involved in carrying hereditary factors. (3) To find how Mendel's laws operate in the transmission of hereditary factors: blood groups in man.

Theory: No organism can exist indefinitely. Therefore, every species must reproduce itself in order to maintain itself on earth. This reproduction may result from the division of the parent body into two nearly equal parts as in the amoeba. The simpler forms of organisms in which no highly developed organ systems are present can simply divide into two parts or develop buds which break off the parent body and start new organisms. This asexual form of reproduction is to be found in organisms as highly developed as the earthworm, although here it is the exception rather than the rule. In the case of these worms the developing of two worms from one occurs when the parent has been cut and the process is called regeneration.

Reproduction by the fusion of structures from two parents occurs in nearly all forms of living organisms, even in many of those which can reproduce asexually. The two parents may be structurally indistinguishable the differences being based on a physiological rather than on an anatomical basis. Or definite structures may be present which can be distinguished as male and female gametes and organs.

In many organisms no provision is made for the caring of the newly formed individual as it develops from a single cell, the zygote, into the fully developed individual. This is true of animals as complex as the amphibians (the frog). The eggs are fertilized by the sperms outside the parent body. Hundreds of zygotes are formed but because of the hazardous conditions under which they develop comparatively few reach maturity. In organisms as complex as mammals we observe highly developed organ systems both for the production of the sex cells, gametes, and for the caring of the young until development has been completed. In such instances it is interesting to note that the number of eggs fertilized is small and the high percentage of this number which reach maturity.

Yet, no matter how simple or complex the process of sexual reproduction, the only parental material passed on from generation to generation is the chromatin material of the nuclei of the gametes. The structures involved are called chromosomes and in these are carried the actual factors, the genes, for the transmission of hereditary characteristics. Factors are present in pairs in individuals, one being

received from the male parent the other from the female parent. Two such factors forming like or contrasting pairs are said to be allelomorphs.

The inheritance of blood groups in man is based on multiple allelomorphs. There are three genes involved. However, only two of these genes can be present in any one individual. *A* represents the gene for antigen A (see discussion below for antigens and antibodies). a^B represents the gene for antigen B, and *a* represents the gene for no production of an antigen. A and a^B are both dominant over a, but neither is dominant over the other. Therefore, if both A and a^B are present, both antigens will appear in the blood. If A or a^B are present with a (Aa or a^Ba) an antigen will appear. Only if aa (two recessive factors) are present do we get the O group (no antigen present in blood). The list below shows the genetic possibilities in regard to blood group factors:

aa—Group O

AA
Aa —Group A

a^Ba^B
a^Ba —Group B

Aa^B—Group AB

When a foreign protein is injected into the blood stream of an animal a substance is produced which reacts with the foreign protein. This substance is produced by the cells of the animal. It becomes abundant in the blood stream, in some cases temporarily and in others permanently a part of the blood serum. The substance produced is called an antibody and the foreign protein an antigen.

Usually antibodies are produced *after* the injection of an antigen. However, there are certain antibodies occurring naturally in the body which do not have to be produced by injections. This is the case with blood groups. The reactions between antigens and antibodies may be of various sorts. In the case of blood reactions the red cells injected (the antigen) are clumped (agglutinated) by the antibodies in the blood stream. Or the red cells of the donee may be clumped by the antibodies in the serum of the blood donor. This reaction does not occur in all combinations of red cells and serums. It is evident that normal antibodies occur in the serum of some people and normal antigens in the blood of others.

There are two kinds of antigens in human red blood cells and two kinds of antibodies in blood serums. The antigens are called A and B. With these two it is possible to have four blood groups. A person with antigen A is in group A; with antigen B in group B; with both A and B in group AB; and with no antigen present in group O. A person with antigen A will have no antibody for this antigen. If he did his red cells would be clumped together, the typical agglutination resulting in death. If antigen A is not present the antibody for this antigen will be. Therefore, one with antigen A in his cells will have no antibody for A, but since antigen B is not present the antibody for B will be. The cells of group AB will be agglutinated by either A or B serum, while group O blood will not clump with either of these serums.

Experiments and Demonstrations

I. Observation of vegetative propagation in plants.
   A. What form of reproduction is this called? Why?
   B. Will the new plants be like the parent or will new characteristics appear in the offspring?
II. Sexual reproduction in the mold, Rhizopus.
   A. Observe the petri dishes labeled the plus strain.

B. Observe those labeled minus strain.
Do you see any formation of spores across the middle of the dish? (Spores are black and will be seen as a black line or region if present.)

C. Can you note any structural differences between the plus and minus strains?

D. Observe petri dishes labeled plus and minus.
What differences do you note between these and the dishes observed above? How can you account for these differences? What has occurred in these petri dishes?
Will the spores formed here develop into a plus or minus strain? Why?

III. Observation of fertilization in the marine alga, Fucus.

A. Note the gametes. Are they alike or different in structure?
Describe their appearance.

B. What is fertilization? What are the resulting structures called?
Are they genetically like the parents? Explain.

C. Where do the new individuals develop?

IV. Observation of mammalian reproductive organs.

A. Pig uterus and embryos.
Identify placenta, foetal membranes, umbilical cord, structure of uterus.

B. Rat uterus and embryos.

C. Dog foetus and membranes.
For B and C identify all parts as in A.
What parental cellular material did the embryos receive from the mother?
How did the embryo receive material for growth?

V. Observation of onion root tip cells showing mitosis and salivary gland chromosomes from Drosophila. Use microscope.

A. In the onion root tip cells identify the cell structures: cell wall, cytoplasm, nucleus.

B. There are many stages of the process of mitosis present in these root tips. Try to identify chromosomes and as many of the stages in the process from mother cell to two daughter cells.

C. Observe chromosomes from the salivary gland of Drosophila, the fruit fly.
Can you see light and dark regions on these structures?

VI. Determination of blood group and genetic background of each individual with respect to this characteristic.

A. On a clean slide place two drops of blood from finger. (Instructor will assist you.)

B. On one drop place one drop of serum A. On the other drop place a drop of serum B.
Allow these to stand 10 minutes.
Observe condition of blood. Compare with pictures in text, *Principles of Heredity,* by Snyder.

C. If blood remains in the same condition as before the addition of the serum, the cells have not been agglutinated. If the cells clump, the serum has agglutinated the blood cells.
What do these conditions indicate with respect to antigens A and B and the antibodies for A and B? (See theory above.)

D. Determine from the above to which blood group you belong.
Using material given in theory above work out:

1. Your possible genetic make-up for blood group genes.
2. The genetic make-up of your parents for this characteristic.
To which blood groups can your parents belong?

RONALD JAMES SLAY

Professor Ronald James Slay, Chairman of the Physics Department, Wagner Memorial Lutheran College, Staten Island, New York, died of a heart attack September 18, 1948. Professor Slay was born in Marthaville, Louisiana, November 15, 1890. He received a B.S. degree from the University of Mississippi in 1912; M.A. and Ph.D. degrees from Teachers College, Columbia University in 1924 and 1928.

Teaching positions included: Head of the Department of Science, Mississippi Normal College, Hattiesburg, Mississippi, 1912–22; Assistant in Department of Physics, Teachers College, Columbia University, 1922–23; Teacher of Science, Lincoln School, Teachers College, Columbia University; Head of Science Department, East Carolina Teachers College, Greenville, North Carolina, 1923–44; Dean and Registrar, East Carolina Teachers College, 1944–45, Dean of East Carolina Teachers College, 1945–47; Wagner College, 1947–48.

Professor Slay was a Fellow in the American Association for the Advancement of Science, a member of the National Council on Elementary Science and for many years a member of the National Association for Research in Science Teaching. His Ph.D. thesis was entitled *The Development of the Teaching of Agriculture in Mississippi.*

ABSTRACTS

POWERS, SAMUEL RALPH. "Science and General Education." *Teachers College Record* 49:373–381. March, 1948.

The trend toward the development of broad integrated experiences allows recognition and study of problems in the setting in which they occur. The challenge of general education is that teachers shall be more concerned with education to improve living and that they shall be concerned with critical social issues and with the personal problems of children and youth, such as those related to personality, growth, and development, and ways of looking at life.

The development of broader science courses than physics and chemistry is a move toward a more favorable situation for dealing with comprehensive problems. The broad course in general biology is well established and that in physical science is gaining recognition.

The goal of science teaching in general education is to help young people to make science as much a part of their lives as it is of the society in which they grow up, work, raise their families, and play their parts as citizens.

Some of the contributions that studies of science have made and are making to personal and social education may be summarized as follows: (1) Understanding of the world and of man and competence to use this understanding to correct the inconsistencies and naïve notions that become obvious in the thinking of young people as they mature, and to use these understandings in their reflections about values. In general, these understandings relate to structure, organization, and change in the universe and in living things. They will include concepts of time, space, force, matter, energy, life, growth, and development, (2) Understanding of the processes and potentialities of technology and competence to use this understanding in directing the utilization of resources, (3) Competence in using the elements of the scientific method that have general application in dealing with personal and social problems. This implies ability to recognize that problems arise out of the search for values and the search for ways to achieve them. It implies the ability to recognize consistency in ideas and concepts about man and the world and society and ability to draw consistent conclusions, that is conclusions that are relatively free from contradictions, and (4) Comprehension of the effects of infiltration of ideas and concepts, scientific in their origins, upon man's conceptions of good and bad.

WILLIAMS, HARRY H. "Implications for Senior High School Courses in Physical Science." *Teachers College Record* 49:415–422. March, 1948.

The problem type of organization is more desirable than the topical or subject-matter approach. The general physical science course which has grown up alongside the traditional courses in physical science is by its nature better adapted to the accomplishment of the purposes of the secondary school. This is largely the result of freedom from subject-matter boundaries. The trend seems to be toward a more functional course with a greater social emphasis. This seems to be psychologically sound.

Science teachers are not adept in using the

scientific method in teaching situations. They seem to do better with helping students to recognize problems and to observe carefully rather than with the ability to reason, to analyze, and see relationships.

EVANS, HUBERT M. "The Challenge of the Atomic Age." *Teachers College Record* 49:406–415. March, 1948.

No one can doubt or question that a new world, the Atomic Age, is here. The new world is definitely here, although in its infancy.

In the new world, energy will be cheap and plentiful. Factories of all sorts will dot the world's landscape. They will be almost completely automatic. Food will be cheap and plentiful. No one need to be ill, at least for long. Many will live to be more than a hundred. There will be much more leisure. No one will have to work long days to produce the needed goods and to perform the needed services.

But there are many hazards in the new world ahead. The destructive power of the atomic bomb cannot be over-estimated.

The school faces four immediate tasks: (1) The first and most important is for the school to take its part in a community-wide effort to reduce ignorance in the critical areas where lack of information and understanding on the part of the citizen can spell disaster, (2) The second task of the school and community leaders is to develop a methodology for the reduction of ignorance which will not only make the informational job more effective, but will also contribute to the development of democratic skills and attitudes without which the information secured would be of little value to the democratic citizen in an Atomic Age, (3) The third task of the school and its community is the deliberate development of democratic attitudes and values, and (4) The fourth task of the school and the community is to reveal to its young people the nature of the work world in the Atomic Age.

FITZPATRICK, FREDERICK L. "Biological Materials in the Program of General Education." *Teachers College Record* 49:398–405. March, 1948.

Biological or any other scientific information can be of only slight benefit to civilization unless it becomes the basis for intelligent decision and action. Some biological materials may be encountered at various maturity levels in the public schools—as a part of elementary science, as a part of general science, and as a biological course on the senior high level. Yet the author quotes the Steelman Report as saying "the science offering . . . has been and still is in many places incidental." Large numbers of pupils may complete the entire curriculum, yet have little or no contact with science instruction. A second criticism is that in many classrooms the materials presented do not implement the purposes of general education. Broad areas in biological science that could be used for purposes of general education include: (1) the adaptations of organizations, (2) the changing environment and its relationship to man's welfare, (3) nutrition, (4) reproduction, evolution, and heredity, (5) biological production, and (6) control of natural enemies and competitors.

CROSS, WILLIAM BURNETT. "The Film in Science Education." *Teachers College Record* 49:427–431. March, 1948.

Almost everything remains to be found out about the techniques of choosing, using, and evaluating films in the classroom as total experiences rather than instructional "aids." The average teacher's lack of conviction as to the real value of the film in the science classroom causes school administrators and curriculum designers to hesitate about putting much faith and money into equipment that is notoriously expensive, reputedly temperamental, and operationally demanding. Science teachers need to have opportunities to see and discuss films useful in the science classroom.

FORBES, WILLIAM C. "Purpose in Laboratory Experiences." *Teachers College Record* 49:423–426. March, 1948.

Germany pioneered (through such men as Francke at the University of Halle in 1695) in introducing the laboratory method in teaching, the central technique being experiment with apparatus and materials. At first the teaching was by demonstration, performed by the professor. Laboratory work was performed by students under Leibig at Giessen in 1826. In the United States laboratory experiments were performed by students in the universities after 1850.

There are two basic types of behavior in the laboratory experience. First, there is direct observation of characteristics, which produces a mental picture and verbal concept; second, there is opportunity to manipulate materials and observe reactions as related factors vary.

The scientific method is experienced by the individual as he concisely defines a problem, sets up an experimental situation involving pertinent materials, recognizes constants and variables as factors involved, records observations with cognizance of degree of accuracy, and determines an answer on the basis of data and legitimate inferences therefrom.

The cooperative or group approach is very often most desirable. Meaningful laboratory experiences are not disconnected from other aspects of the student's life. Laboratory work is meaningful to the student only if it is purposeful to him.

JOSEPH, ALEXANDER. "The Best from the Science Laboratories of Experienced Teachers of Science." *The Science Classroom* 37:1, 4. April and May, 1948.

These two issues describe a series of interesting demonstrations in science: (1) One fifth of the air is oxygen by A. Arthur Capson, (2) Consumer education and junior high school science by Morris B. Daniels, (3) Transformations of energy by Emanuel Kalish, (4) How Alibi-"R"

Operates by Alexander Joseph, and (5) A demonstration to develop pupils' ability to observe and make hypotheses by Lee B. Cottrell.

STRANG, RUTH. "Principles of Readability Applied to Reporting Research." *Teachers College Record* 49:449–451. April, 1948.

If research is worth doing at all, it is worth reporting so that it will be read. It must be readable. If research workers apply the fundamental principles of composition: coherence, unity, and emphasis, research workers will write more often and be read.

The principle of appeal. Interest increases readability.

The principle of personalization. Application of this principle puts human interest into the report. Here are several ways in which this can be accomplished:

1. The writer can review the previous investigations as a story of the other person's successes and failures, leading up to the need for the present study.
2. He can tell how he collected and treated the data. There is drama in methodology.
3. He can use illustrative cases to make concrete the generalizations which he derived from statistical treatment.
4. He can describe and explain deviations from central tendencies.

The principle of patterning. Every research has a design that should be made plain to the reader. The writer needs a sense of structure of sentences, of paragraphs, of the chapter or article as a whole.

The principle of emphasis. The writer should make certain that the reader gets the important points. Too frequently the main ideas are submerged in a welter of words.

The principle of dilution. A report of research can be too concentrated. Too great density of ideas may make reading difficult. Brevity may be puzzling.

The principle of plain words. First, the writer should avoid empty words—fillers in that do not carry essential ideas. Second, he should use short, simple, concrete words whenever possible. Avoid technical words as much as possible.

WALKER, HELEN M. "Statistical Understandings Every Teacher Needs." *Teachers College Record* 49:452–457. April, 1948.

This article relates only to the general needs of the ordinary classroom teacher as he deals with pupils and meets his responsibilities as an educated citizen. Such a teacher needs a general idea of the meaning of an average, of variation, of concomitance, of sampling, of how to interpret charts and tables. The most important thing educated persons—including teachers—need to know about statistical method is the uses which can be made of it. Teachers need some understanding of the universality of human variability. Too often statistical data is wrongly and harmfully interpreted. Concomitance is often confused with causation.

DAVIS, W. ALLISON, AND HAVIGHURST, ROBERT J. "The Measurement of Mental Systems." *Scientific Monthly* 66:301–316. April, 1948.

The authors discuss the question: can intelligence be measured? Present mental tests do not represent a sufficiently wide range of mental systems and mental problems. Culture of the respondent necessarily and inevitably influences the responses to all items in all tests of general intelligence. Circular validation has been the only method of validating mental tests. Academic types of problems need to be reduced if the tests are to determine the relative mental status of individuals who have grown up in different socioeconomic levels in the United States. Problems used should be equally common and equally motivating to all socioeconomic groups. Problems selected need to be objectively validated in some other manner than by circular validation now used.

VINACKE, W. EDGAR. "The Basic Postulates of Psychology." *The Scientific Monthly* 67:110–114. August, 1948.

Modern thinking in psychology may be characterized by the following:

1. The material of behavior. The same fundamental variables are present in the total behavior of all human beings, although all degrees of these variables may be observed; differences between individuals are largely differences of degree rather than of kind.
2. Uniqueness. Every individual, as a total personality, is different from every other individual, as a result of past experience in conjunction with heredity, because no combination of factors is ever precisely the same for any two individuals.
3. Normality. "Normal" behavior is a relative matter; it is that behavior which characterizes most people within a given cultural group (with certain privileged exceptions, such as the artist). "Abnormal" behavior is extreme deviation from a given average point in terms of a defined variable or group of variables.
4. Physiological concomitants. Every manifestation of behavior in an organism (here, the human being) occurs in association with some physiological change; no human behavior can take place without some change in the organism.
5. Heredity—environment. The human organism, like all living things, is the joint product of heredity and environment; no aspect of the behavior of an individual is entirely independent of either heredity or environment.
6. Socialization. Human behavior of any sort can be fully understood only in terms of the social context in which it is developed and in which it functions.
7. Objectivity. No interpretation of human behavior can be fully accepted unless it is founded on fact substantiated by scientific evidence.
8. Finality. In the study of human behavior, no interpretation, conclusion, or law, is necessarily final, but is given in the light of the best

present knowledge; allowance must be made for the possible operation of unknown or uncontrolled variables and for other limitations of knowledge or outlook.

9. Modification. Human behavior is not static; the individual develops and his behavior is modified and remains modifiable as long as life continues.

10. Measurement. Potentially all human behavior can be measured and described.

11. Diverse views. Human behavior may be, and has been, interpreted from different viewpoints, no one of which is necessarily right or wrong, and all of which may contribute to complete understanding.

12. Fractionation. If, for convenience, aspects, or parts, of human behavior are studied separately (or if apparently divisible units are analyzed), it cannot be fully understood or described in terms of these elements, but must finally be viewed as a whole organization.

13. Dynamic. All human behavior has a cause.

BETZ, WILLIAM. "Functional Competence in Mathematics—Its Meaning and Attainment." *The Mathematics Teacher* 41:195–206. May, 1948.

This is the summarization of an address delivered at the Indianapolis meeting of the National Council of Teachers of Mathematics. The article presents certain critical appraisals which have been made regarding mathematics. Then follows an extended discussion of functional competence in mathematics and how this may be attained.

SYMPOSIUM. "Elementary School Self-Evaluation." *Pennsylvania School Journal.* March, 1948.

The following major and subtopics comprise this excellent reprint: 1. Teachers and children live and learn together in a good school: (a) a sound philosophy is the starting point of a good school, (b) the curriculum is everything a pupil learns, (c) a good school has good tools, (d) instruction is adjusted to individual differences, (e) good discipline is growing self-control, (f) good health is a first concern of a good school, (g) growth is a yardstick by which we measure, (h) home-work is a home-school relationship, (i) reports to parents are important; 2. School personnel is the greatest single factor in a good school: (a) the professional staff sets the educational "climate" of the school, (b) the non-professional staff also contributes to the "climate" of the school; 3. A good school plant keeps pace with a good curriculum: (a) a good school is clean and orderly, (b) a good school is safe and healthy, (c) a good school is attractive, (d) a good school is efficiently arranged; 4. A good school is a community school: (a) the school utilizes all community resources to enrich the curriculum, (b) the community is encouraged to use the school facilities, and (c) the community is kept informed of the needs and objectives of the school.

AUKERMAN, JR., ROBERT C. "Differences in the Reading Status of Good and Poor Eleventh Grade Students." *Journal of Educational Research* 41:498–515. March, 1948.

This study was made to determine: do good and poor-eleventh grade students with intelligence and other factors held constant differ in reading ability? The students were paired on the basis of intelligence, sex, color, age, subject, grade level, hour of recitation, and teacher. There were 19 pairs in English, 18 in American History, 16 in Mathematics, and 20 in Chemistry.

The study made use of general reading test, specific reading tests in the four fields, tests of specialized types of reading, general vocabulary tests, and specific vocabulary tests in the four fields.

Results of the study indicate that general reading ability is the most significant differentiating factor between good and poor eleventh grade students in all four academic fields. In chemistry, good students were superior to poor students in reading materials in science and in all other academic fields, in reading material classified as "general" in nature, and in specific vocabulary knowledge.

HERZOG, ELIZABETH G., AND SHEATSLEY, PAUL B. "Science Education as the Scientists See It." *The Educational Forum* 12:413–426. May, 1948.

American scientists register enthusiasm about the quality of graduate education in science, give undergraduate work a passing grade, and mildly flunk high school science instruction.

These are among the major findings of the first systematic survey of scientists' opinions, conducted by the National Opinion Research Center during the Spring of 1947, for the President's Scientific Research Board.

Only a minority believe that high school science teachers are doing a good job, but they believe that most colleges are doing an excellent or good job of training students to teach high school science. Over one-half rate the job as excellent or good, and only about a third call it fair or poor. The leading complaint about high school science education centers on the teachers—above all on their lack of background and training. "They don't know enough" is the most frequent criticism.

SYMPOSIUM. "Teacher Training." *Journal of Educational Research* 41:641–717. May, 1948.

This issue comprises seven articles dealing with some phase of teacher education.

Teacher Recruitment and Selection During the Period 1944 Through 1947 by R. H. Eliassen and Robert L. Martin summarizes 193 studies (listed by title in the bibliography) under 14 main headings including personality, intelligence, liking for children, knowledge of subject matter, and so on.

Summary of the Relation of Personality Adjustments of Teaching by M. Elizabeth Barker summarizes the author's study on the personality adjustment of teachers.

A Suggested Procedure for the Selection of Prospective Teachers at the End of the Sophomore Year in College by Blanche G. Bobbitt suggests some procedures for the selection of teachers. These include mental, achievement, and reading aptitude tests, high school and college grades, and opinions of instructors.

The Selection of Teacher Interns by Clifford L. Bishop discusses factors that should be considered in the selection of teacher interns. The three most important were: (1) Personal attitudes most desired in teachers, (2) Evidence of freedom from emotional defects, and (3) General undergraduate record or scholastic average.

In-Service Education of Teachers Through Cooperative Curriculum Study by Lester M. Emans summarizes an investigation in which cooperative curriculum study programs were found to be an effective method of in-service education of teachers.

The Status and Function of Men Teachers in Urban Elementary Schools by Louis Kaplan indicates that more men should be teaching in elementary schools in the opinion of a vast majority of psychologists and educators.

Wisconsin Studies of Teaching Ability by A. S. Barr reports progress of the Wisconsin study. Twenty-four studies at present under way are briefly described.

Fisher, Virginia W. "Occupational Guidance in High School Chemisty." *Journal of Chemical Education* 25:90–93. February, 1948.

Occupational guidance in high-school chemistry should begin with the first class period. On the first day many students ask "Why am I taking chemistry and how can I use it?" Occupational information should be given throughout the course.

Check lists of desirable qualifications for chemistry include: mental ability, accuracy, keen observation, mental alertness, patience, sound judgment, interest, self-reliance, good imagination, industrious, ambitious, responsible, use of data, good health, enthusiasm, initiative, logical reasoning, cheerfulness, loyalty, curiosity, render service, calmness, perspective, cooperative, and good study habits.

There is a somewhat extensive list of books, journal articles, and free industrial pamphlets on occupation information.

Deming, Horace G. "Guinea Pigs in the Classroom." *Journal of Chemical Education* 25:445–449, 462. August, 1948.

Students subject to instructional experiments in the classroom are truly guinea pigs to be used by the instructor in a search for better methods of instruction. The author now professor of chemistry in the University of Hawaii and a well-known textbook writer, says that early in his teaching career he became aware of an important law: Every student has credit on the registrar's books for several preparatory courses that he cannot actually use. Every instructor needs to be sensitive to defects in students' backgrounds and be willing to remedy them.

The article describes the techniques used by the author to achieve his main purpose in teaching students chemistry—the ability to think. Drill is emphasized at first. Open-book examinations are given later in measuring this ability to think. Plans for written examinations include the student's making a carbon copy and grading his own paper.

Laboratory techniques receive emphasis at first through a series of dozens of little problems. Original thinking with a minimum of directions is emphasized later. An attempt is made to make students reason out *why* things happen.

Ogburn, William F., and Adams, Jean L. "Are Our Wars Good Times?" *Scientific Monthly* 67:23–33. July, 1948.

The effect of war is generally considered to be destructive. Certainly, such it is in battle and in a country that is being bombed or invaded. Otherwise, the destruction is limited to materials and lives lost outside the home country. There are also constructive effects of war as the authors point out. The consequences of war are much more than loss of life and property. The article compares the conditions of recent wars in the United States with the conditions in peacetime. Statistical records of production, unemployment, divorces, and marriages are used. War is not easily discernible in some records. Wars have an adverse effect in such areas as highway construction, public debt, and divorces. On the whole, however, war years are good years as judged by various indices of good times.

Stollberg, Robert. "Finding Out How Magnets Behave." *The Instructor* 57:48. September, 1948.

This elementary science unit describes the making and behavior of magnets.

Stollberg, Robert. "The Science Corner." *The Instructor* 67:58. October, 1948.

Three musical instruments that can be made by elementary science pupils are described: xylophone from sticks of wood, a pipe organ from test tubes, and a bugle from a rubber hose and a funnel.

Worthy, Eunice. "A Unit on Different Types of Homes." *The Instructor* 57:30, 91. September, 1948.

This is a primary unit on homes that includes: objectives, procedure, kinds of homes, integrations, and results.

Scotten, Clyde Foster. "Rocks Help Make the Soil." *The Instructor* 67:33, 78, 88. October, 1948.

This is a middle and upper grades unit. Included are: objectives, subject matter (how rocks are made, kinds of rocks, how soils are made, kinds of soid, according to texture, kinds of soils classified according to location, conservation of soil), and activities.

Davis, Helen M. "Laws of Matter Up-to-Date." *Science News Letter* 53:394–395. June 19, 1948.

This is a compilation in 74 statements of the known facts about the nature of matter.

Underwood, R. S. "Two Telescopes and the New Universe." *Scientific Monthly* 67:5–16. July, 1948.

Many excellent photographs supplement the author's discussion as to some of the information the new 200-inch telescope may supply. It may answer the question as to whether our present sample of the universe is typical; it may tell us whether the apparent expansion of the universe is real; it should tell us much more about the chemistry of all things, both far and near; it may determine whether we are nearing the limits of the universe in so far as space is concerned; it should greatly enhance our knowledge of the solar system; it may bring about important intellectual readjustment in our thinking about the universe.

Anonymous. "Creation of Galaxies." *Science News Letter* 54:71. July 31, 1948.

Dr. George Gamow of George Washington University announces a new theory of the creation of the universe. When the universe was a tenth as old as it is now, the great masses of stars called the galaxies (like our Milky Way) were formed. It took that time, 300,000,000 years, from the beginning of things for the universe to evolve into the general shape that it is now.

In the beginning all creation was a highly compressed gas made up of neutrons. The stuff of the universe was completely made in about one hour. In the complex formulae that show the relation between the microcosmos of the atomic nuclei and the macrocosmos of the stellar galaxies, Dr. Gamow uses the elementary charge, the quantum constant, the mass of the proton, the velocity of light, Newton's gravitational constant, and the binding energy of the deuteron. From this, Dr. Gamow derives the diameter of the stellar galaxies as 12,000 light years and the mass of the galaxies as 15,000,000 times the mass of the sun.

Schneider, Burch H. "The Doctrine of Ahimsa and Cattle Breeding in India." *The Scientific Monthly* 67:87–92. August, 1948.

The doctrine of Ahimsa has its roots in the belief in reincarnation. The orthodox Hindu abhors the idea of killing an animal, especially cattle, because he believes it might have the soul of man from a previous incarnation. Hence cattle are used chiefly for draft and milk purposes. Advances have been made in improving draft cattle but relatively little in milk cattle. Chances of improvement are almost hopeless. India has about one third of the world's cattle. They are the humped Brahman or Zebu, especially suitable for tropical climates.

Gregg, H. Raymond. "The Magnificent Rodent." *The Scientific Monthly* 67:73–82. August, 1948.

The beaver population has greatly increased in the last forty years through protective measures that have been in effect. From an original estimate of 60,000,000 in population to a point of almost total elimination, followed by the recent increase in total numbers is the history of the beaver in the United States. From a rarity in all states to a common sight in many states has been brought about by enlightened conservation measures. In 1946 the value of beaver pelts ranged from $1,188,925 in Wyoming, to $702,880 in Wisconsin, $394,360 in Michigan, $272,323 in Colorado, and $255,000 in Montana. The illustrated article depicts many of the life habits and activities of the beaver.

Mann, Martin. "You Can't Escape Cosmic Rays." *Popular Science* 153:139–143. July, 1948.

Cosmic rays, first discovered some thirty-five years ago, continually bombard the earth. In their bombardment of particles of the earth's atmosphere, mesons are created. Mesons weigh about 200 times as much as electrons and seem to be of several kinds. These mesons can have a single negative charge (like an electron), a single positive charge (like a proton), or be neutral (like a neutron). The origin of cosmic rays is not known, but many believe they come from outside the solar system, while others believe the sun itself is the actual source. At any rate, the basic radiation from outer space seems to be almost exclusively protons.

Mesons go through the body as light through a window. Standing up you are riddled by 1500 mesons a minute; lying down (exposing more body area), by 7500 a minute. Carbon produced from the air's nitrogen by cosmic rays, is in all animal and vegetable carbon. But a little radioactivity doesn't seem to hurt us. The normal human body even contains some radium. And of the body's 10 ounces of potassium, about one part in 1000 is radioactive "potassium 40." Thus radioactive carbon in the body produces less radiation than radioactive "potassium 40," but more than the radium.

BOOK REVIEWS

OAKES, MERVIN E. *Children's Explanation of Natural Phenomena.* New York: Bureau of Publications, Teachers College, Columbia University, 1948. 151 p. $2.35.

This is the report of a doctoral study made at Teachers College, Columbia University. The specific aim of the study was to analyze the answers given by four groups (grade levels) of school children and one group of adults (college teachers in non-science courses) to direct questions regarding various natural phenomena and to classify their explanations. Some of the problems were presented as purely verbal questions and others as simple experiments. The study is descriptive and qualitative rather than quantitative and statistical.

The subjects were children attending the Practice School of the State Normal School at Fredonia, New York: 77 in Kindergarten, 24 in Grade II, 24 in Grade IV, and 28 in Grade VI. (The report on the "Explanations of Natural Phenomena by Adults" was published in Science Education 29:137–142, 190–201 April and October, 1945).

Data for the study, patterned after a similar study by Piaget, were obtained through interview by the investigator himself. A wide range of scientific information was explored. Many questions were obtained from Piaget, some from other investigators, and a number were added by the author. No attention was paid to sex differences. Most of the children's responses were matter-of-fact and naturalistic. Answers classified as physical were numerous in each grade group, increasing in number from grade to grade: (K., 47.4%, II, 72.6%; IV, 78.4%; and VI 81.9%). Conversely Non-Physical responses decreased from grade to grade: K., 18.6%; II, 12.2%; IV, 12.0%; and VI, 6.5%.

A comparison between responses of subjects with the highest I.Q.'s and those of subjects with the lowest I.Q.'s shows no large differences with respect to the types of explanations given.

Each subject, regardless of age, mental ability, or grade level, gave explanations of a wide variety of types. No evidence was found to corroborate Piaget's interpretation that there is a definite stage in the child's thinking which is characteristic of a given age.

In general, understanding of essential relationships increases with age among children.

In general, there is a close similarity between these findings and those of other recent investigators, but they differ considerably from those reported by G. Stanley Hall and Piaget.

An extensive bibliography of 398 titles concludes the study.

Altogether the study is an outstanding contribution to research in science education, and especially the elementary science field. Much tedious research is evident and is supported with some unusually good analytical diagnosis. Thus by slow degrees has elementary science advanced to a position of great importance in the elementary school program. This advance has been made possible by this and other similar outstanding research studies.

C. M. P.

FRIEDMAN, BERTHA B. *Foundations of the Measurement of Values.* New York: Bureau of Publications, Teachers College, Columbia University, 1946. 227 p. $2.75.

This is a doctor's dissertation in which the investigator focused her attention on the determination of the status of the individual's motivations.

The author states the purpose of her study, then proceeds to discuss the underlying theory of value and of motivation. Definition of value and the location of values is discussed in the following two chapters. The quantitative determination of values is most difficult and only slight progress has been made in this area. Following this discussion the author discusses methods of measuring how much a person values an object. Many of the investigations that have been made are based on the theory that an object gets its value from the fact that individuals value it. The method, therefore, is to get a number of persons to appraise the same object.

The author devised a set of thirteen wish questions suitable for children of the upper elementary grades. The children wrote free-response answers to each of these questions. A check-list was then prepared from the free-response answers. Items were then classified into twelve categories.

The author also had twenty-five women keep a diary notebook for a period of two weeks. A Time and Money value scale was worked out on the basis of the analyses of diaries. Then a questionnaire relating to Time and Money was given to 203 boys and girls of Grade IX in junior high school in New York City.

The study should prove useful to those interested in value measurement as well as to those persons working in the field of interest, attitude, and personality testing.

C. M. P.

SYMPOSIUM. *Summary of Recommendations of Groups Interested in Special Aspects of Education.* Department of Public Instruction, Division of Elementary Education, Harrisburg, Pennsylvania. 72 p. January, 1948.

This mimeographed bulletin summarizes the work of several state committees. 1. Alcoholic drinks, stimulants, and narcotics education, 2. Character and citizenship education, 3. Conservation education, 4. Consumer education, 5. Home and family living education, 6. Humane education, 7. Intercultural education, 8. Nutrition education, and 9. Safety education.

C. L. D.

HEIMERS, LILI. *Free Films.* Upper Montclair, New Jersey: New Jersey State Teachers College, Teaching Aids Service of the Library, 1947. 40 p. $1.00.

Arranged alphabetically by distributor, this is a rather extensive listing of silent and sound films (with a few slides and filmslides) which may be borrowed rental free. While useful to all teachers, science teachers will especially find a wide variety of film listings.

Remittance (no stamps) must accompany any order. C. M. P.

GOON, FRANCES, MARTIN, CHARLES W., AND O'BRIEN, JR., JOHN J. *Mathematics Visual and Teaching Aids.* Upper Montclair, New Jersey: New Jersey State Teachers College Aids Service of the Library, 1947. 30 p. $0.75.

Charts and maps, devices, exhibits, films, slides and filmslides, games, pictures, publications, and recordings useful in the teaching of mathematics are listed.

After a chapter listing materials for general information, the listings are by subjects: arithmetic, algebra, geometry, trigonometry, and advanced mathematics.

Mathematic teachers should welcome such an excellent source of materials for the enrichment of their courses. Remittance (no stamps) must accompany any order. C. M. P.

WILLEY, ROY DEVERL AND YOUNG, HELEN ANN. *Radio in Elementary Education.* Boston: D. C. Heath and Company, 1948. 441 p. $3.50.

The possibilities and limitations of radio, both in specific areas of elementary instruction and for general enrichment, are explored in this volume. It is written for students who plan to teach in elementary schools and many specific suggestions are made for the use of the radio.

Radio is recognized as a dynamic educational force which has had limited use in the classroom. Techniques of teaching by radio are considered. The uses of radio in teaching in various specific areas such as physical science and nature study are made specific.

The last two parts of the volume considers the administration of radio education and radio's past and future. Radio will have a much more important place in school rooms in the future than it has at present. C. L. D.

GRACE, ALONZO G. (Chairman) *Changing Conceptions in Educational Administration.* Chicago: The University of Chicago Press, 1946. 186 p. $2.50.

This is Part II of the Forty-Fifth yearbook of the National Society for the Study of Education. It supplements to a very large degree the yearbooks for 1945. Chapters are: *Reorientation of Educational Administration* by Grayson N. Kefauver; *The State and the Educational System* by Alonzo G. Grace; *Developing and Administering the Curriculum and Pupil Services; Organizing the Personnel of a Democratic System* by Willard B. Spalding; *Participation in Community Co-ordination and Planning* by Herold C. Hunt and J. Paul Leonard; *The Financial Support of Education* by Alfred Dexter Simpson; *Providing Appropriate Housing for Schools* by Charles Bursch; and *The Professional Preparation of School Personnel* by Alonzo G. Grace. The latter chapter discusses: 1. initial selection of trainees, 2. continued guidance and follow-up, 3. adequate professional preparation, 4. effective specialization, 5. personality development, 6. scholarship, and 7. final recommendation of the candidate. Some reasons for failure in the administrative field are: 1. failure to keep the policy-determining board informed, 2. lack of sense of timing, 3. inability to make decisions, 4. inability to keep pace with social change, 5. dealing with a part of the board, 6. unwillingness, or inability to democratize procedures, 7. critical judgment about a predecessor, 8. inability to present a point of view clearly and forcefully, 9. a fear of citizen organizations, 10. inability of being a good listener, and 11. failure to develop a program. C. L. D.

BARNHART, CLARENCE L. (Editor) *The American College Dictionary.* New York: Harper and Brothers, 1948. 1432 p. $6.00.

The American College Dictionary is the first really new college desk dictionary in more than ten years. It is the first which is neither a revision of an earlier dictionary nor an abridgement of a large one. Eighteen editors and 355 authorities in 316 fields of knowledge were responsible for the selection and definition of terms. The contributors are listed by special fields, which also lists their industrial or college connection. There are 132,000 entries, 1600 illustrations and spot maps, and 1000 groups of synonym studies. Many practical suggestions are included in the dictionary, e.g. a guide to letter writing, manuscript, and proof, proofreader's marks, signs and symbols used in various areas of knowledge, rules of punctuation and mechanics, pronunciation guide, colleges and universities of the United States, and so on.

The binding is washable, heavy-duty black buckram, embossed in lead. The paper is of excellent quality and non-glare. Altogether it is an unusually fine dictionary—one that any college or secondary teacher or student or layman will be glad to have on his desk both because of its practical usefulness and also the improved appearance it adds to the general display of books. C. M. P.

PEIK, WESLEY G. *The Improvement of Teaching.* Washington, D. C. (1201 Sixteenth Street N.W.): National Commission on Teacher Education and Professional Standards, 1948. 168 p. $1.00.

This bulletin is based on the group reports of the Oxford Conference at Miami University, Oxford, Ohio on July 3, 4, 5, 1947. The Introduction summarizes the addresses presented at the opening general session. Part one sets forth the

conclusions and recommendations of seven Conference groups working on the broad problem of improving the profession itself. Part two is based upon the reports from five conference groups studying the improvement of the educational program. Part three presents the findings of four conference groups concerned with improving the school environment and teaching situation. Part four deals with improving school-public relations as seen by four conference groups working in that area. A list of conference participants showing their respective work groups, is included in the appendix. C. L. D.

VERRILL, A. HYATT. *Strange Prehistoric Animals and Their Stories.* Boston: L. C. Page and Company, 1948. 262 p. $3.75.

There have been few, if any, writers who could equal A. Hyatt Verrill as a popularizer of science. A book by this expert raconteur is always a reading enjoyment to be looked forward to with unusual anticipation. His tales are never humdrum or commonplace, but often have all of the suspense of a good detective story. *Strange Prehistoric Animals and Their Stories* is no exception to the many fascinating books written by Mr. Verrill.

In this book the author takes us back to the very beginning of life and through picturesque descriptions and clever drawings makes very real the weird, comical, grotesque animals, that once roamed the earth. There is no absolutely satisfactory explanation for the disappearance of these prehistoric animals. A few "out-of-place" animals have survived down to the present time.

The author discusses the creatures of myth and fancy such as dragons, mermaids, sea serpents, hydras, phoenixes, fauns, and so on. He points out their place in legends and primitive religions and suggests that they were more than figments of man's imagination.

This is an excellent supplementary reader for all junior and senior high school boys and girls, teachers on all levels, and any layman interested in an interesting story well told.

Earlier interesting books by the same author include:

Strange Insects and Their Stories, Strange Sea Shells and Their Stories, Strange Birds and Their Stories, Strange Reptiles and Their Stories, Strange Fish and Their Stories, My Jungle Trails, Mineral Metals and Gems, Strange Animals and Their Stories, Strange Customs, Manners, and Beliefs, The Incas Treasure House, Perfumes and Spices, and *Foods America Gave the World.* C. M. P.

CROUSE, WILLIAM H. *Understanding Science.* New York: Whittlesey House, McGraw-Hill Book Company, 1948. 190 p. $2.00.

This is one of the most delightful science books on the junior-senior high school level that has appeared in sometime. The outstanding developments of modern science and basic science phenomena are explained in simple, concrete language. A wide range of science discoveries and inventions are discussed: steam and internal-combustion engine, electricity, telephone, phonograph, radio, light, photography, motion pictures, television, radar, airplanes and jet planes, atomic structure, atom bomb, and atomic energy.

Numerous and clever illustrations by Jeanne Bendick on almost every page add much to clearness and interest of the discussions. A helpful bibliography is found at the close of the book.

The reviewer recommends *Understanding Science* as an unusually fine book for the school library, for boys and girls in their teens, and even for the science teacher. C. M. P.

RUNES, DAGOBERT D. (Editor). *The Diary and Sundry Observations of Thomas A. Edison,* New York: Philosophical Library. 1948. 247 p. $4.75.

Anyone who is familiar with the life and work of Edison will appreciate the excerpts from his diary which are given in this book. For instance, at Menlo Park, New Jersey, Sunday, July 12, 1885,—sixty-three years ago, we find Edison a very happy man and he describes the day in such a way that one wonders that he did not become a poet. He states, "This is by far the nicest day of this season, neither too hot nor too cold—it blooms on the apex of perfection—an Edenday. Good day for an angel's picnic. They could lunch on the smell of flowers and new mown hay, drink moisture of the air, and dance to the hum of bees. Fancy the soul of Plato astride of a butterfly riding around Menlo Park with a lunch basket."

He found Encyclopedia Brittanica helpful as a source of information to steady his nerves before retiring.

Edison was almost Franklinian in his defiance of the doctrines of pure science. He was an experimenter and a practical man rather than an ingenious theoretician. His inventions were the product of a methodical and prodding mind. There were no sudden flashes of accidental discovery in his realm.

The chapters on *War and Peace, Education and Work* are most timely. Edison said, "There are two slogans which I wish every magazine would print in the most conspicuous place in their publications. These are, first, 'To begin with the youth of America and teach them not only the love of good music, but also to play on some musical instrument, as well as cultivating the voice'; second, 'The Necessity of good teachers in America'". The great inventor asked the question, "Why do so many men never amount to anything" He answered the question with this statement, "Because they don't think," and he added, "I am going to have a sign put up all over my plant, reading, "There is no expedient to which a man will not resort to avoid the real labor of thinking."

This book will be placed on my book shelf along with Garbedian's "Thomas Alva Edison, Builder of Civilization" as a truly great book. F. M. D.

Yates, Raymond F. *New Television: The Magic Screen.* New York: Didier Publishers, 1948. 175 p. $2.75.

With his unusual facility at making technical scientific ideas understandable to the layman, Mr. Yates in *New Television* has written a most readable treatise in electronics. For not only does this book explain television but also other areas of electronics such as the electron microscope, teleran (radar television), sonar (under sea radar), the "snooperscope," and the "sniperscope." Numerous photographs and illustrations supplement the textual material.

Thoughtful laymen, high school science teachers, and boys and girls of the 'teen age with a "yen" for radio and electricity will find the book most interesting and understandable. The book is highly recommended for the high school science library.

C. M. P.

Anonymous. *Gasoline by Synthesis.* New York (30 Rockefeller Plaza): Standard Oil Company of New Jersey, 1948. 22 p. Free.

This illustrated pamphlet contains information that teachers of elementary science, chemistry, conservation, and geography will find most interesting and useful. It is excellent for units on petroleum, coal, and conservation.

G. B. K.

Evans, Ralph M. *An Introduction to Color.* New York: John Wiley and Sons, Inc., 1948. 340 p. $6.00.

This is probably the finest non-technical book that has been written on color. It is non-mathematical and does not pre-suppose the reader to have a knowledge of either physics or psychology beyond first principles. However the book is not to be regarded as altogether elementary.

The coverage is broad: physics, psychophysics, and psychology. In the first part the author takes up the sources of light and the objects and substances that modify it; in the second section the author deals with the evaluation of purely physical light by purely mechanical means; in the discussion on the psychology of color the author discusses the relationship between color as calculated for the standard observer and color as actually perceived by the mind.

Chapters are devoted to color and light, colored objects, color vision, the visual variables of color, perception and illusion, brightness perception, color differences and color names, mixtures of colored lights, effects of illuminants, transparent colorant mixtures, paints and pigments, color in photography, and color in art.

There are 304 illustrations, including 15 full-page color plates. The author is head of the color control department of the Eastman Kodak Company. This is an excellent book for the physical science survey teacher and student, the high school physics and general science teacher, and those persons interested in color from the standpoint of art.

C. M. P.

Knobloch, Irving William. *Readings in Biological Science.* New York: Appleton-Century-Crofts, Inc. 1948. 449 p. $3.00.

Primarily this volume is intended to be read in conjunction with a textbook, and used in this way, it should accomplish much in achieving the goals of a basic biology course. The author is associate professor of Biological Science in the Basic College at Michigan State College. The volume starts with material on life and the cell and then follows a general scheme of watching the green plant make organic food, of animal nutrition, circulation and so on. Finally there are several articles of a philosophical nature, serving to integrate the various aspects of biological science.

Excerpts and material are taken from the writings of numerous leaders in biological science: Hippocrates, Aristotle, Pliny, Van Leeuwenhoek, Darwin, Huxley, Peattie, Garbedian, Ward, Matzke, Carlson, Wilder, Guyer, Morgan, Fenton, Conklin, Newman, Haggard, Jiffe, Verrill, Osborn, and so on.

This is an excellent supplementary reading reference for the elementary science, general science, and biology teacher, and also the high school student.

J. O. S.

Gamow, George. *Biography of the Earth.* New York: New American Library, 1948. 193 p. $0.35.

This breezy little pocket sized booklet is one more welcome addition to the popularly written scientific literature. It is really a readable digest of geology—historical—plus the necessary astronomical support. There are a number of good sketches, line drawings and diagrams, and a few half-tones are furnished. The usual difficulty of compromising scientific exactitude and popular diction is met quite well, but with occasional over-confidence in figures and predictions.

F. A. Riedel.

Jeans, Sir James. *The Growth of Physical Science.* New York: The Macmillan Company, 1947. 364 p. $4.00.

This book traces the growth of the physical sciences from many small beginnings to their present domination of the thoughts and actions of men. The author is eminently qualified for such a task. The late Sir James Jeans was one of the foremost astronomers and mathematical physicists of our time. Probably no Englishman in the whole realm of science was as well known to American men of science as Jeans. Many readers will recall his popular *The Stars in Their Courses, The Universe Around Us, Through Space and Time, The Mysterious Universe, The New Background of Science, Science and Music,* and *Physics and Philosophy.*

The author starts with the Babylonian system of counting and multiplying and ends with today's mystery of sub-atomic energy. Man began by treating himself and his earth as the center of the whole universe. Knowledge has shattered

that confidence. Yet the great accomplishments of man in unravelling the mysteries of life and the universe stand as the great accomplishment. As in his earlier books, the author in clear and dramatic language writes in a style that will appeal to and is understandable by the educated layman. C. L. D.

UDANE, BERNARD AND GILLARY, HERMAN W. *Student's Handbook of Science.* New York: Frederick Ungar Publishing Company, 1948. 208 p. $0.75.

The reviewer can best describe the nature and purpose of this handbook by quoting from the Foreword by Dr. Paul F. Brandwein, Chairman of the Science Department of the Forest Hills, New York, High School and Lecturer in Teachers College, Columbia University, "This little book should be in the hands of every science student—not because all science students are to be scientists but because all of them need to know whether they are fitted for a science career, whether they are getting the most out of their work in science, whether they can improve their study, and how science can contribute to their enjoyment of living."

A wealth of information and suggestions are contained in this handbook. The four parts are divided into thirty-one chapters: vocational opportunities for the science student, opportunities in civil service, aptitude tests, scholarships, science courses, planning your program, extra curricular science activities, school record, how to study, how to keep a good science notebook, how tc make science drawings, how to write a science report, how to make a science project, science magazines, science radio programs, places of scientific interest, nature study, bird watching, entomology, plant studies, microscopy as a science hobby, photography as a science hobby, astronomy, rocks and minerals, meteorology, do you want to become a radio ham, other science hobbies, science organizations, purchasing your science supplies, and building your science library.

Each chapter has a carefully selected list of supplementary reading material. The authors are science teachers in the Forest Hills, New York, High School. Not a bad book for the science teacher, too! C. M. P.

SCIENCE CLUBS OF AMERICA. *Sponsor Handbook.* Washington, D. C. Science Service, Inc., 1948. 98 p. $1.00.

No science club sponsor should do without this Handbook and science teachers not sponsoring a science club will find the Handbook very useful. It discusses methods of how to organize a science club, activities, projects, how to get publicity, science service aids for science clubs, how to conduct a science fair, recommended books, and free and low cost materials. The reviewer regrets that such a helpful Handbook was not available to him while he was sponsoring science clubs for many years.

C. M. P.

COMMISSION ON POST WAR PLANS. Guidance Pamphlet in Mathematics for High School Students. New York (525 W. 120th St.) *The Mathematics Teacher,* 1948. 25 p. $0.25.

This is the final report of the Commission on Post-War Plans. It is to be used by high school students, and by guidance personnel, parents, school administrators, and mathematics teachers. It gives many reasons why the high school student should know something about mathematics. It is very specific both for the everyday layman and for those making little or great use of mathematics in making a living.

Various aspects discussed include: (1) mathematics for personal use, (2) mathematics used by trained workers, (3) mathematics for college preparation, (4) mathematics for professional workers, (5) women in mathematics, (6) mathematics used by civil service workers, (7) mathematical organizations, (8) graduate schools offering the doctrate in mathematics, and (9) selected references in mathematics. S. M. A.

PARTRIDGE, E. DEALTON. *Visual Teaching Aids for High School Physics.* New York: American Book Company, 1948. 48 p. $0.60.

This is a teacher's manual to accompany *Physics* by Walter G. Whitman and A. P. Peck.

The teacher of physics now has available a great variety of teaching aids. These aids exist in a wide variety and are adaptable to varied teaching situations. The bulletin board, motion pictures, and filmstrips are emphasized in this publication. Names of films and filmstrips with their respective sources are listed for each chapter of the Whitman-Peck *Physics.* Not only is this publication a most valuable resource and teaching aid for users of that particular text, but teachers of other physics texts will find the pamphlet of great use to them. C. M. P.

BENNETT, H. *The Chemical Formulary Volume VIII.* Brooklyn: Chemical Publishing Company, 1948. 448 p. $7.00.

Users of the previous volumes of *The Chemical Formulary* will welcome this new volume. Many teachers have found using the earlier editions an excellent way of promoting interest in chemistry. It is not only an excellent source of many supplementary projects for the regular laboratory work, but it is a wonderful source of pupil projects in the science club. Through its use many boys and girls have been convinced of the practical usefulness of chemistry. The book contains a fund of ideas, information, data and formulae otherwise unavailable to the general science and chemistry teacher.

Directions and proportions for making a large variety of materials are given: adhesives, cosmetics, drug products, emulsions and dispersions, farm and garden preparations, food products, ink, insecticides, fungicides, weed killers, lubricants, construction materials, metals, paints, paper, photography, plastics, rubber, resins, waxes, polishes, textiles, soaps and cleaners, pyrotechnics, and explosives. S. M. A.

ZIMMERMAN, O. T. AND LAVINE, IRVIN. *Scientific and Technical Abbreviations, Signs, and Symbols.* Dover, New Hampshire: Industrial Research Service, 1948. 476 p. $7.50.

Abbreviations, signs, and symbols are indispensable tools of the scientist and technologist. They not only save incalculable amounts of time and space, but without them many of the simple tasks of today would be virtually impossible to carry out. This convenient volume lists the principal ones and should result in greater uniformity and to their increased use.

Scientific and technical workers and writers will find this a time-saving volume. Many fields are covered: engineering, mathematics, chemistry, physics, radio, electronics, astronomy, commerce, banking, machine and tool shops, and so on.

S. M. A.

LAURIE, ALEX AND KIPLINGER, D. C. *Commercial Flower Forcing.* Philadelphia: The Blakiston Company, 1948, 550 p. $4.75.

This is the fifth edition of a text first published in 1934. Many new ideas in application are included in this revision. Biology teachers at the high school level will find many interesting and useful ideas. Those biology teachers having a greenhouse will especially appreciate this practical treatise. S. M. A.

GABOR, D. *The Electron Microscope.* Brooklyn: Chemical Publishing Company, 1948. 164 p. $4.75.

The Electron Microscope serves both as introduction to the use of the electron microscope and also as a critical contribution to its theory. Construction details are given and the preparation of specimens discussed.

The electron microscope while relatively new has been rapidly extending its usefulness and unlimited possibilities remained to be revealed.

S. M. A.

FORRESTER, J. DONALD, ET AL. *Principles of Field and Mining Geology.* New York. Prentice-Hall, Inc., 1948. 680 p. $7.00.

The above senior writer together with three others have produced a real contribution to applied geology literature. The rigorously scientific phases are closely knit with the definitely practical, by authors highly capable in the industrial field. The authors claim, and the text seems to support this, that the text embraces much hitherto unavailable material; it speaks to the practical man in terms of his actual needs and field operations and ends with the highly important techniques of evaluation of pay properties. The preparation of maps, models, illustrations: the working out of interpretations of field observations and related mapping and evaluation receive full consideration. A bibliography and full glossary top off an altogether laudable effort. The appendix of tables and measures is welcomed. F. A. RIEDEL.

SCHNEIDER, HERMAN AND NINA. *Let's Look Inside Your House.* New York: William R. Scott, Inc., 1948. 40 p. $1.50.

This is another picture-science book by the authors of *Let's Find Out, Now Try This,* and *How Big Is Big?* It is suitable for boys and girls of about the 7-11 age group.

Pupil experiments are interspersed with the illustrated textual material. How water flows up in the house, water pipes, and reservoirs receive first consideration. Under heat is considered: how water carries heat, radiators, air circulation, and the furnace. The unit on electricity considers: pushbutton magic, complete circuits, switches, conductors, electric lights, electric heat, electric power, and electric safety. A picture quiz completes the book. F. M. D.

STONE, GEORGE AND NOBLE, DORIS. *The Wonderworld Readiness.* New York: Charles Scribner's Sons, 1948. 96 p. $1.00.

This is a science readiness book for the first grade. The authors in the preface state that "six-year-old children have the spirit and attitudes of true children. They are interested in investigating their surroundings and are anxious to find answers to their questions. Science experiences are therefore particularly valuable for young children and might well represent the major portion or core of classroom activities. *The Wonderworld Readiness* will give each child a pleasurable introduction to science. The vocabulary was carefully selected and limited to a minimum number of words."

Carefully selected, challenging pictures in color, with appropriate phrases and sentences will arouse the interest of first graders. The following science areas are explored: living things, seasons, sunny days, cloudy days, the sun goes down, and animals and their young. Five pages of suggestions to teachers are included. Altogether this is an unusually attractive science book, entitled to be placed among the finest elementary science books that have been published.

F. M. D.

FENTON, CARROLL LANE. *Wild Folk at the Pond.* New York: The John Day Company. 1948. 127 p. $2.00.

In the front of the book information is given to parents and teachers which should be of great value to them in selecting reading material for children four to twelve years of age. It states, "This is the second book in a series telling the stories of animals that live in varied surroundings, or habitats. The stories also mention a few plants, for animals could not live where they do if plants were not present. The first book in the series, *Weejack and His Neighbors,* for ages four to eight deals with creatures that are common on farms, in woods and vacant lots, and even in city parks. *Wild Folk at the Pond* describes animal life that is found in the ponds and the creeks that flow to them. Many things belong to the pond community. We encounter some lowly ones such as clams and snails, as well as

insects, crayfish, and several kinds of animals that have vertebrae, or backbones. Each one represents an important group of living things and an important way of living. Thus Es-see raccoon is cared for by his mother, but Croaker Green Frog grows up without even knowing who are his parents. Graywing, the heron, hunts food for himself and his nestlings, but the mussel takes whatever comes in the water she brings into her body. Turtles and dragonflies have no special home, but Diver and red-winged blackbirds build nests, while kingfishers dig a tunnel and an underground room in which they rear their young." The book is easy to read and simply written.

The author, Dr. Carroll Lane Fenton, is one of America's best and most authoritative writers in biological and geological science. Earlier books include *Life Long Ago, Earth's Adventure, Along Nature's Highway, Along the Hill* and *The Story of Geology for Young People*.

F. M. D.

ELEMENTARY EDUCATION. *Local Participation in State-Wide Revision of the Elementary School Curriculum.* Bulletin 233-A, 1946. Department of Public Instruction, State of Pennsylvania. Harrisburg, Pennsylvania.

This excellent bulletin, out of print for a considerable time, has been widely used by the teachers of Pennsylvania and even outside the state. Considerable reference to the bulletin is made by Laversia L. Powers in her article in the October issue of *Science Education*.

Chapter headings are as follows: 1. Proposed curriculum development program, 2. How to work in study groups, 3. The setting of the school curriculum, 4. The program of studies, 5. Administrative organization to implement the growth philosophy, and 6. Making the classroom a living democracy.

C. M. P.

BURNETT, R. WILL, JAFFEE, BERNARD, AND ZIM, HERBERT S. *New World of Science.* New York: Silver Burdett Company, 1948. 504 p. $2.80.

The approach in this ninth grade science is functional. The authors included most of the subject matter found in similar ninth grade books, but only if the subject matter contributed to an understanding of the problems and concerns of today. To help provide a series of rich and significant science experiences, *New World of Science* includes numerous suggestions for science activities of many kinds. These include suggestions for experiments, demonstrations, field trips, class discussions, exhibits, individual library or laboratory research committee reports, and class projects. These suggestions, called "Working with Science," appear at the close of each section of each chapter throughout the book. References, briefly annotated, for pupils and teachers are found at the close of each chapter. A teacher's guide "The Resourceful Teaching of New World of Science" includes many concrete suggestions for teachers and a list of 150 carefully selected, up-to-date teaching films.

The reading material is replete with numerous drawings and photographs that add much to the reader appeal and interest. The only question the reviewer has regarding this unusually excellent book is the difficulty of subject matter. Only wide usage by many general science pupils with greatly varying experiences, reading abilities, and interests will determine whether it is too difficult in reading level for many of the ninth grade students. In all likelihood this will not prove to be the case for the three authors are men of wide, practical experience. The senior author, Dr. Burnett, is well known for his *Biology for Better Living, To Live in Health,* and *Life Through the Ages.* Dr. Jaffee is author of *New World of Chemistry, Crucibles, Outposts of Science,* and *Men of Science in America.* Dr. Zim is a well known popularizer of science through his *Mice, Men and Elephants; Elephants, Rabbits, Goldfish, Minerals* (with Cooper), *Plants, Rockets and Jets, Parachutes, Submarines, Man in the Air, This Is Science,* and *Science Interests and Activities of Adolescents.*

C. M. P.

RAWLINS, GEORGE M. AND STRUBLE, A. H. *Chemistry in Action.* Boston: D. C. Heath and Company. 1948. 568 p. $3.00.

This high school text embodies an organization which meets wide acceptance with modern educators—a few well-chosen units and supporting problems. These are arranged in a logical order that gives due attention to pupil-appeal. A preview of each unit is a welcome feature. Illustrative cuts are abundant, timely and appropriate. At the close of each chapter are questions in good variety, grouped according to difficulty. A few selected references follow. The use of problems gives flexibility in selection and arrangement for assignment purposes. The newer chemistry—that of electrons and the nucleus—receives intelligible and adequate treatment at the intended level. An appendix of terms, tables, references, formulas, laws, etc., is an excellent component of this very readable, modern, and teachable text.

F. A. RIEDEL.

RITCHIE, JOHN W. *Biology and Human Affairs. Yonkers,* New York: World Book Company, 1948. 818 p. $2.68.

First published in 1948, the primary purposes of this high school text are cultural and practical. It intends to leave the student with certain important appreciations, concepts, and attitudes. The author attempts to combine three methods of teaching biology: the type method, the systematic or group method, and the principles methods. The larger organization of the book is by emphasis on principles. There is an abundance of material, permitting the teacher to use a wide selection if that seems desirable. Seasonal selection is easily possible.

Each unit begins with an overview and is divided into a series of problems. Many illustrations and photographs supplement the reading material.

Aids to study include groups of questions at the end of each unit designed to test comprehension of facts and ideas of the unit; "Suggested Activi-

ties and Applications"; pupil and teacher references. The type is rather large and the paper non-glare. With smaller page size than many similar high school biology texts, the actual amount of material in this book is not greatly in excess of that of a number of books in this field.

Altogether, biology teachers will find this a practical classroom text, quite readable both as to technical vocabulary and literary style.

C. M. P.

AMES, MAURICE U., AND JAFFE, BERNARD. *Textbook in Chemistry*. New York. Silver Burdett Company. 1947. 47 p.

The busy instructor will be delighted with this very complete booklet of questions covering a first course in chemistry. All units found in the authors' laboratory guide and the text, are covered. The questions are of the objective, mainly completion, multiple choice, and matching types. The answer blanks are conveniently placed at the right hand margin for easy, rapid scoring. Most of the items are free of ambiguity and language difficulties. Daily and "semester" tests are provided.

F. A. RIEDEL.

AMES, MAURICE U. AND JAFFE, BERNARD. *Laboratory and Workbook Units in Chemistry*. New York: Silver Burdett Company, 1947. 275 p.

For those who find convenience and expert outside help in written instructions for the laboratory, this workbook should be welcomed even more than its predecessors. There are 59 "units" or exercises. There is a rich supply of excellent line drawings, open tables, and abundance of "Fill-ins" covering an extensive variety of questions and problems, so grouped as to cover minimum and maximal needs. Single or double laboratory periods are provided for. The recent excellent revision of a widely used text by the junior author will almost of itself recommend this edition of the laboratory guide. The directions are very readable and practical. The overall effect is not that of an all too common cookbook style but appeals to the reviewer as being challenging, up to the minute and educative in influence.

F. A. RIEDEL.

SMALLWOOD, WILLIAM M., REVELEY, IDA L., BAILEY, GUY A., AND DODGE, RUTH A. *Elements of Biology*. Boston: Allyn and Bacon, 1948, 691 p. $2.72.

Elements of Biology is a new, postwar textbook for high school use. New in content, organization, and format so say the authors in the format. They have attempted to retain the simplicity and interest which characterized their earlier books. New discoveries and investigations are included.

Intentionally and definitely the book has been planned to avoid the characteristics of many of its present competitors in high school biology. The authors believe that there is a real desire on the part of secondary biology teachers to get back to a greater emphasis on the fundamentals of animal life and plant life. They are convinced that pupils will be more interested and challeneged by such an emphasis and that the amount pupils learn will be greatly increased. They have tried to make *Elements of Biology* a vital, human book through an emphasis on the everyday world of living things.

The organization of content is intentionally seasonal. Animal life is introduced in the fall of the year when weather conditions are suitable for out-door activity. Mankind is studied in the winter when charts and models can be used. Plant study comes in the spring when new life begins to appear. There are 463 illustrations and charts designed to create interest in and understanding of, the textual material. Special projects, including laboratory exercises, learning and achievement tests, full-page classification charts, many references, and a detailed glossary form an integral part of the text. A teacher's handbook and a pupil workbook add much to the usefulness of the book. Undoubtedly the book will be widely used, welcomed alike by users of the former editions, and by other teachers desiring a change from what they have been using.

C. M. P.

GREENE, ROBERT A. AND BAILEY, GUY A. *New Laboratory Manual*. Boston: Allyn and Bacon, 1948. 244 p. $1.12.

This laboratory manual is to accompany Smallwood's et al. textbook in biology reviewed above. It is really a workbook designed to aid the student in his study of biology. There are questions to be answered, drawings to label, suggestions as to further work, observations to make, conclusions to be drawn, and so on. Three simple refresher tests are included in the workbook.

C. M. P.

SORENSON, HERBERT AND MALM, MARGUERITE. *Psychology for Living*. New York: McGraw-Hill Book Company, 1948. 637 p. $3.90.

One will find few textbooks in psychology written in as lively and interesting style. It should hold the interest and undivided attention of the high school boys and girls for whom it is intended. It seems to the reviewer that it goes to the very center of many of the problems and needs of adolescent youth. It is unfortunate that we seldom if ever, find a comparable book dealing with the problems of a beginning teacher. That is a major reason why so many prospective teachers find little relationship between the psychology studied in college and the actual classroom teaching situation.

Teachers will not only enjoy teaching the book, but youth will thoroughly enjoy reading and discussing the book. It is written in clear, concrete language and in a friendly, appealing manner, replete with many case histories. Each chapter begins with provocative questions and ends with a summary and set of exercises.

Such important topics are discussed as habits from the viewpoint of personal welfare; growth and personality; intelligence and mental ability; how to think straight; how to study and learn effectively; courtship; romance and marriage;

and how to get the right job and hold it. This is a book that all junior and senior high school teachers as well as parents of that age youth would enjoy reading. C. M. P.

MEREDITH, FLORENCE L. *Health and Fitness.* Boston: D. C. Heath and Company, 1946. 325 p. $2.20.

This is an unusually fine high school text on health and hygiene. The author has had many years of practical experience both as a teacher and in actively practicing medicine among students. Her college textbooks on hygiene and health are probably more widely used than any other similar publications. Their wide and long usage attest the excellence of the books. This high school text will undoubtedly further the high opinion held of the author and her writings.

The information given in this book is authoritative, practical, and challenging. It is psychologically organized in a literary style and vocabulary that will appeal to high school boys and girls. An excellent and suggestive teacher's manual accompanies the text.

The book would serve as an excellent reference for high school biology teachers and students, and also for the elementary science teacher. C. M. P.

WELTE, H. D., KNIGHT, F. B., AND WALKER, L. S. *Self-Help Geometry Workbook.* Chicago: Scott, Foresman and Company, 1948. 84 p. $0.72.

This workbook contains 34 drill exercises and 6 self-help study exercises. There is a teacher's guidebook and answer key for the workbook. G. B. K.

STULL, DEFOREST AND HATCH, ROY W. *Our World Today Geographies Series* (revised edition). Boston: Allyn and Bacon. 1948.

The reviewer was a student of the late DeForest Stull at the time he was writing the first edition of this series of textbooks. He realized that there was a great need for better textbooks in the field of geography and he perhaps succeeded in writing one of the best, if not the best geography series for the elementary grades that has ever been published. He believed we should proceed from the known to the unknown and upon this theory the books are most ably developed.

PIERCE, MARY LUSK. *The Community Where I Live.* 1947. 132 p. $1.40.

This is the first book in the series and it is for beginners. De Forest Stull taught in his classes that the basic needs of man are food, clothing, shelter, fuel, tools and implements, and luxuries. (Water, sunlight and air are things it is assumed we all have). The children may learn considerable Geography outside the classroom. They can learn about land formations, sun, water, air, seasons and weather. This little book is a delight to the pupils and makes the teaching of Geography a most happy experience for the teacher in the primary grades. As the Series was initially planned, this textbook was to be used in the third grade or in the second and third grades where those two grades are combined as they often are. I see no reason why it could not be used progressively through the second and third grades.

STULL, DE FOREST AND HATCH, ROY W. *Journeys Through Many Lands.* 1948. 160 p. $1.72.

This textbook of the *Our World Today* geography series is designed for the fourth grade and is the second in the series. Accompanying this book is a *Geography Workbook for Journeys Through Many Lands,* by Stull and Hatch.

Also there is a teachers manual for *Journeys Through Many Lands.* How could a teacher be better equipped to teach the fourth grade Geography than to have this most excellent text, workbook, and manual?

STULL, DE FOREST AND HATCH, ROY W. *Journeys Through North America.* 1948. 328 p. $2.40.

The third book in the series and for the fifth grade, is *Journey Through North America.* Accompanying it is a workbook, *Geography Workbook for Journeys Through North America* by Stull and Hatch and a Teachers Manual. The manual completes the most carefully prepared material for the fifth grade teacher.

STULL, DE FOREST AND HATCH, ROY W. *Europe and Europe Over Seas.* 1948. $2.40.

This is a sixth grade and the fourth book in the series. A teacher's manual and workbook accompany it. Our teaching of the geography of Europe, has in the past perhaps been the weakest link in the elementary school geography chain. This textbook is designed to give the sixth grade pupil a thorough knowledge of the geography of Europe.

STULL, DE FOREST AND HATCH, ROY W. *Our World Today—Asia, Latin America, and United States.* 1948. 338 p. $2.40.

This book is the fifth in the series and it is designed for the seventh grade. A workbook and manual accompanies it.

The textbook material was carefully worked out and the Horace Mann School, Teachers College, Columbia University was used as a laboratory to test with actual classroom use the materials presented in the series.

The social implications are stressed throughout the series. Today's geography is a study of international problems and of human ecology. It is a most colorful series, replete with interesting and challenging pictures for the pupils, a lively literary style, non-glare paper, and most readable type. Properly taught, practically all pupils are much interested in geography and enjoy studying it. No other series of elementary school geographies has so much to offer both the pupil and the teacher. Any teacher failing to interest pupils in geography when using these texts would quite likely be a failure in teaching geography whatever geography text is used.

F. M. P.

Atwood, Wallace W. and Thomas, Helen Goss. *Neighborhood Stories; Visits In Other Lands; The American Nations; Nations Overseas; The United States in the Western World.* Boston: Ginn and Company, 1945, 1948. 234 p. 216 p. 388 p. 392 p. 312 p.

This widely used series of elementary geography texts has been revised and completely brought up to date. Altogether the series comprises one of America's most popular geography textbook series. They have been carefully graded for vocabulary and reading difficulties. Numerous photographs, illustrations, and excellent maps add both to the teachability of the books and the pupil appeal. Many student helps are included.

A pupil workbook is available for each text. The workbook includes many fill-in blank questions and pupil activities. The teacher's manual and key for each text has many suggestions for teaching each specific part of the textbook.

Progressive school men recognize the vital importance of each child having a basic understanding of the world in which he now lives and in which he will likely play an important part as an adult. No person can claim to be educated today who does not have a functional knowledge of the geography of the world which he must react to daily and progressively interpret his environment. The Atwood-Thomas series is an excellent one for giving the child a functional, correct view of the earth and its people as an integral part of his total environment.

F. M. P.

Finch, Vernor C., Trewartha, Glenn T., and Shearer, M. H. *The Earth and Its Resources.* New York: McGraw-Hill Book Company, 1948. 584 p. $3.20.

This is the second revised edition of a high school text book in physical geography or earth science. Flood control, soil conservation, the use of ultra-violet light in the search for valuable minerals, the use of radar in weather study are among the many new topics discussed.

There are numerous and well-planned illustrations (463), review questions, suggested activities, topics for class reports, and references at the end of each chapter. The atmosphere, weather, and climate receive quite comprehensive treatment both in the textual material and in the appendix. High school students using this as a text will have an excellent knowledge of the earth on which they live. The book will serve as an excellent reference for general science teachers, and for students in physical science survey courses.

G. B. K.

McPherson, William, Henderson, William Edward, and Fowler, George Winegar. *Chemistry at Work.* Boston: Ginn and Company, 1948. 676 p. $2.88.

This is the revised edition of a chemistry text that has had wide usage over a long period of years.

The subject matter is organized into 13 units with 53 chapters. Each unit begins with an overview and each chapter and each unit closes with a list of questions, a list of related exercises and problems, and a list of supplementary readings and films. The subject matter is that found in most high school chemistry texts and is designed primarily to give those students studying it a fundamental background of chemistry, whether the student enters engineering, medicine, or the pure science field upon going to college.

G. B. K.

Burns, Elmer E., Verwiebe, Frank L., and Hazel, Herbert C. *Physics: A Basic Science.* New York: D. Van Nostrand and Company, 1948. 674 p. $2.88.

This is the second edition of a high school text first published in 1943. The material is divided into 25 units consisting of 81 chapters. Consequently several of the units and many of the chapters are quite short. Students using the book and mastering it will obtain an excellent knowledge of, and insight into, the subject of physics. They will have an excellent background for entering engineering schools, and college courses in physics and chemistry. Many illustrations supplement the reading material. Many challenging statements, illustrations, and problems are included. Most chapters have an excellent list of student projects, a list of summary questions, and "A" and "B" list of general questions and an "A" and "B" list of problems. This text should prove challenging and interesting to the pre-engineering and pre-science major student.

G. B. K.

Keller, M. Wiles and Zant, James H. *Basic Mathematics.* Boston: Houghton Mifflin Company, 1948. 253 p. $1.50.

Basic Mathematics is a workbook written for those students who need a thorough understanding of the fundamentals of basic mathematics, including arithmetic, algebra, some geometry, and trigonometry. The authors have endeavored to write the book so it can be used either by a student working independently or as a basic text in a class under the supervision of an instructor.

A diagnostic test has been placed at the beginning of each of the three major units. Comprehensive achievement tests have also been included. The material seems to have been well selected and anyone having an understanding of the material presented will have a functional knowledge of the major concepts in these areas.

C. M. P.

Black, Newton Henry. *An Introductory Course in College Physics.* New York: The Macmillan Company, 1948. 800 p. $5.00.

This is the third edition of a text first published in 1935. It had wide usage during World War II and this new edition is based upon the experience then gained. Much technical material, of interest only to the physicist, has been omitted. A series of descriptive questions have been inserted at the end of each chapter. The approach is historical.

G. B. K.

ELDER, ALBERT L., SCOTT, EWING C. AND KANDA, FRANK A. *Textbooks of Chemistry.* New York: Harper and Brothers, 1948. 758 p. $4.50.

This is the second revision of a book first published in 1941. The theoretical part of the book has been completely rewritten and the descriptive matter brought up to date. There are many advantages to the authors placing most of the theoretical part first—within the first hundred pages before the study of oxygen and hydrogen. These two elements are followed by a discussion of liquids, solids, solutions, acids, bases, ions, salts, and chemical equilibria. G. B. K.

GUYER, MICHAEL F. *Animal Biology.* New York: Harper and Brothers, 1948. 780 p. $4.50.

The fourth edition of this wellknown text represents a complete revision. More than 475 colleges have used the earlier editions as a text. It is a highly accurate, scientifically sound, and scholarly work. The author is one of America's best known zoologists. Many readers will remember especially his *Being Well-Born: An Introduction to Heredity and Eugenics.*

S. M. A.

TANNER, FRED WILBUR AND TANNER, JR., FRED WILBUR. *Bacteriology.* New York: John Wiley and Sons, Inc. 1948. 625 p. $4.50.

This is the fourth edition of a book first published in 1928. It is intended for those beginning the study of microorganisms for the first time, although it is not elementary in nature. It would also serve as an excellent supplementary reference for high school biology, general science, and elementary science teachers. C. M. P.

CURRIER, ARNOLD J. AND ROSE, ARTHUR. *General and Applied Chemistry.* New York: McGraw-Hill Book Company, 1948. 275 p. $3.00.

This brief college chemistry text is designed for students in applied science and technology who will normally take only one year of college chemistry. Such students may be found in agriculture, engineering, home economics, and other applied sciences. The authors believe that most beginning chemistry texts contain too much material for the above named groups of students. The book attempts to correct the stated defect. G. B. K.

SHREWSBURY, J. B. *An Approach to Radio.* Princeton, Kentucky: Electronics Industries, 1947. 288 p. $4.50.

This book attempts to give a working knowledge of the fundamental principles of radio, each in its proper relation to the others together with the manipulative skills to put them into practice. The book is written for informational reading by the general public, as an introduction for the prospective student, and, when used in combination with the prescribed construction materials, as a beginning unit in the study of radio. The average high school physics teacher should be able to build a course around the text.

The print is unusually large, easily read, and is on high quality paper. Many illustrations supplement the textual material. G. B. K.

SLURZBERG, MORRIS AND OSTERHELD, WILLIAM. *Essentials of Radio.* New York: McGraw-Hill Book Company, 1948. 806 p. $4.00.

This is not a beginners book on radio, but rather at an intermediate level. It seems to be quite comprehensive and asserts that only a minimum of mathematics is used. However it would be quite difficult for most high school physics teachers.

On the other hand it would seem to be excellent for those persons having a good basic course in radio at the college level. S. M. A.

LONG, J. S. AND ANDERSON, H. V. *Chemical Calculations.* New York: McGraw-Hill Book Company, 1948. 401 p. $3.75.

This is the fifth edition of the widely used text on problems and calculations in general chemistry. While most of the material deals with the introductory phases of chemistry, there is some material on gas analysis, thermochemistry, and electro chemistry. High school chemistry teachers would find this book most helpful.

S. M. A.

MAXIMOW, ALEXANDER A. AND BLOOM, WILLIAM. *A Textbook of Physiology.* Philadelphia: W. B. Saunders Company, 1948. 700 p. $8.50.

This is the fifth edition of a book first printed in 1930. It has become very popular as a textbook. Its popularity is due to its authoritativeness, readability, excellent general appearance, its wealth of illustrations (total of 562, many in color), excellent bibliographies at the end of each chapter, and an unusually good index.

S. M. A.

TURNER, C. DONNELL. *General Endocrinology.* Philadelphia: W. B. Saunders Company, 1948. 604 p. $6.75.

General Endocrinology is intended as a beginning text for students concentrating on experimental biology. The material is approached from the experimental rather than the clinical point of view. High school biology teachers and biological science survey course teachers and students will find this an unusually readable and interesting supplementary reference.

S. M. A.

TODD, JAMES CAMPBELL, SANFORD, ARTHUR HAWLEY, AND STILWELL, GEORGE GILES. *Clinical Analysis by Laboratory Methods.* Philadelphia: W. B. Saunders Company, 1948. 954 p. $7.50.

This is the eleventh edition of a book first published in 1908. Clinical pathology has undergone marvelous development during these forty years. This edition has been completely revised and much new material has been added.

This new edition will probably retain the place of leadership held by the earlier editions.

S. M. A.

LIKES, CARL J. AND HARVEY, JR., A. E. *First Year Qualitative Analysis.* New York: Thomas Crowell Company, 1947. 134 p. $1.25.

This little booklet is suitable for short college courses or for the high school courses terminating in a period of analytical exercises. The material is logical, but graded according to difficulty. Equilibrium calculations are not neglected. The Bronsted theory, ionic and molecular equations are featured. Sample cases are worked out. Good explanatory notes and final practice exercises are furnished, as well as a periodic chart and logarithms. The appendix is quite complete and serviceable. F. A. RIEDEL.

BLAIR, THOMAS A. *Weather Elements.* New York: Prentice-Hall, Inc., 1948. 353 p. $4.25.

The textbook in meteorology, *Weather Elements,* thoroughly revised for its third edition, incorporates new concepts and basic data on: air masses and fronts, weather analysis and forecasting, aviation as related to weather, world weather relations, and climatic influences. Rewriting material avoids a common fault of lengthening the later edition. Every section is renovated without "changing the general manner and order of treatment."

When first published, Blair's book was a pioneer publication in the field for the United States. It was very well received both at home and abroad, by specialists and laymen interested in the study of atmospheric phenomena. The work was heralded as authoritative and conservative, containing comprehensive information on theoretical and practical phases of meteorology and climatology. While Associate Professor in the Department of Geography at the University of Nebraska and Senior Meteorologist for the Weather Bureau in Lincoln, Nebraska, the author had ample opportunity to test the validity of theories and to utilize teaching tools and methods.

For reference work and classroom teaching the earlier editions are popular with students and instructors alike. Peculiar ability is displayed in simplifying complex problems by careful choice of words and meaningful examples. This latest, improved edition, like its predecessors, will adequately serve as a basic source and standard text in the elements of meteorology.

DAVID C. WINSLOW.

GREGORY, JAS. S. AND SHAVE, D. W. *The U.S.R.R.: A Geographical Survey.* New York: John Wiley and Sons, Inc., 1944. 636 p. $4.50.

The authors have given us a timely well-organized and reliable account of the geography of Russia. The geological background is necessary and is adequately developed for the purpose. Maps, tables, though not abundant, are well executed. The climate of course receives its share of attention as a prime factor in determining geographical influence. In line with modern broad geographical treatment the practical—social, industrial, and economic consequences of the environment receive full treatment and in very readable fashion. The chapters on the flora, the historical and political considerations indicate the very broad as well as intensive structure of this text. The particular regions in this vast and varied sixth of the world's inhabitable area are dealt with separately and in relation to the whole of the U.S.S.R. The reader is left with a sense of the enormity of this once obscure territory and a feeling of awe at the consequences for civilization upon the future motivation of this extremely important segment of our world.

F. A. RIEDEL.

ALBRIGHT, J. G. *Physical Meteorology.* New York: Prentice-Hall, Inc., 1947. 383 p.

Dr. Albright has prepared a concise and comprehensive treatment on the subject of physical meteorology. He presupposes an adequate background in physics on the part of the reader. His discussions, however, are not of such depth as to hamper serious scholars. References are limited, but little outside literature appears necessary in pursuance of the subject matter.

Application of techniques to practical situations is largely ignored. For illustration, snow measurement is embraced by a brief statement of one common method. It appears an incentive for learning would be provided by pointing out other possible modes of accomplishing results in the field. Likewise, practical application of the obtained information in actual problems would be stimulating.

Weather observers, conservationists, and others might desire an additional chapter on water gauges and other devices frequently encountered in their work. Although such instruments are not strictly used for analysis of the atmosphere, they are invaluable for correlation with weather phenomena.

Physical Meteorology is a timely and well-written textbook and should be on the shelf of every authority and serious student.

DAVID C. WINSLOW.

WELLMAN, WILLIAM R. *Elementary Industrial Electronics.* New York: D. Van Nostrand Company,, Inc., 1948. 371 p. $3.20.

Beginners can readily understand this book on electronics. It is written, not from viewpoint of the engineer but directly to students, electrical maintenance men, and workers in allied fields who need a basic knowledge of electronics and its various industrial applications.

A survey type of introduction outlines the major applications in non-technical terms. The use of mathematics has been reduced to a bare minimum. High school physics students will find the book most readable and instructive.

G. B. K.

AMBERSON, WILLIAM R., AND SMITH, DIETRICH C. *Outline of Physiology.* New York: Appleton-Century-Crofts, Inc., 1948. 502 p. $5.00.

This is the second revision of a most readable textbook in physiology. The approach is historical, adding considerably to the interest in reading the book. The book has many pertinent illustrations. Biology teachers will find the book an excellent reference. S. M. A.

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ABSTRACTS

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AUTHORS

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